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A LAND OF SKELETONS.

By R. LYDEKKER, B.A. Cantab.

NEXT to Australia, which, as regards its fauna, stands quite apart from the whole of the rest of the world, South America possesses a greater number of peculiar types of animals than any other region at the present day. A traveller, for instance, starting from Europe may wander eastwards across the northern part of Asia, as far as Japan, without ceasing to meet with types of mammals and birds perfectly familiar to him; while the same is, to a great extent, the case if his footsteps are directed to India or Africa. It is true, indeed, that in both the latter countries he will come across creatures like elephants and rhinoceroses which are now unknown in Europe, while in Africa he will be confronted by hippopotami, giraffes, and ostriches. All these animals, however, once existed in Europe during the later portions of geological history, and may, accordingly, be counted as pertaining to the European fauna. Still more striking is this similarity of the fauna with that of Europe if the traveller's route happen to lie across the northern half of the New World, where he will meet with many mammals, such as the bison, grizzly bear, and wapiti, which are scarcely to be distinguished, even specifically, from their Old World allies; while others, like the reindeer, wolf, and fox, are absolutely identical. On the other hand, when South America is reached, it will be found that not only are all the mammals and birds specifically different from those of Europe, but likewise that many of them belong to genera or groups absolutely unknown beyond the confines of that country, while Old World types are relatively scarce. For instance, the whole of the typical representatives of that group of mammals technically known as edentates,* such as the armadillos, ant-eaters, and sloths, are exclusively confined to South and Central America; while the monkeys of that continent are quite different from those of the Old World, and the pretty little marmosets are peculiar to it. The camel-like animals known as guanacos and vicunias, together with their domesticated representatives the llamas, are likewise at the present day exclusively characteristic of South America, although there is reason to believe that they were originally introduced from the north. Then, again, opossums (which, by the way, must not be confounded with the creatures commonly so called in Australia) are among the most characteristic of South American mammals, although some range as far north as the United States. The rodents, or gnawing mammals, are likewise remarkable, not only for their numerical abundance, but likewise for the large size of several of their members which belong to genera peculiar to the continent. Among these the capivara or carpincho (*Hydrochærus*), commonly known as the river hog, is the largest living member of the order, its skull measuring about a foot in length. Another characteristic aquatic type is the coypu (*Myopotamus*), generally termed by Europeans nutria, which is properly the Spanish name for an otter, and easily recognized by its red incisor teeth. Of the terrestrial species the most familiar is the viscacha, which inhabits warrens, like the prairie marmot of North America, with which, however, it has no affinity. Not only is South America remarkable for the number of peculiar types of mammals it contains, but it is likewise noteworthy for the absence of a number of Old World and North American forms; especially notable is this paucity among the ungulates or hoofed mammals, which are represented solely by the aforesaid guanaco and its allies, by a group of deer differing considerably from all Old World species, although represented in North America, and by several species of tapirs—the latter animals being at the present day known elsewhere only by a solitary kind from the Malayan region, although they were formerly abundant over a large portion of the Old World. Consequently, such well-known and important groups of ungulates as the oxen, goats, sheep, antelopes, horses, rhinoceroses, hippopotami, and elephants are totally unknown in a wild state at the present day in South America, although two of them, viz., horses and elephants, formerly existed there. Equally characteristic are the birds of South America. Although it will only be possible here to make allusion to a few among these, we may especially mention the entire group of humming birds, together with a peculiar family of perching birds commonly known as wood-hewers, and technically as the *Dendrocolaptidæ*, of which the well-known oven bird (so-called on account of its dome-shaped mud nest) is a familiar example. The large gallinaceous birds termed curassows and guans are also very characteristic; while still more distinctive of the country are the tinamus, which, although structurally allied to the ostriches, are so like partridges in form and habits that by English residents in the country they are commonly so termed. Another characteristic South American bird which is commonly misnamed by Europeans is the rhea; this bird, which is almost universally designated an ostrich, differing from its African relative by having three toes instead of two. Yet another remarkable avian type is to be found in the large and somewhat goose-like chaja (pronounced chahá), or horned screamer, which

* See article on "Armadillos and Aard-Varks."

takes its English name from the spur on its wing and its loud cry—the latter being sometimes heard when the bird is so high in the air as to be almost or quite invisible. Among characteristic South American reptiles may be mentioned iguanas (a name often applied incorrectly to lizards from other parts of the world) and caimans; the latter being a group of alligators, distinguished by having an armour of bony plates on the under as well as on the upper surface of the body. The huge horned frogs (*Ceratophrys*) are likewise distinctive of the country among the batrachians.

Such are a few of the leading features of the existing fauna of South America, which are sufficient to show how totally different is the animal life of this country from that of all the rest of the world. If, however, we go back to the late geological periods of the earth's history, we shall find that this peculiarity and distinctness of the South American fauna was even more intensified than it is at the present day; this being largely due to the circumstance that at one time the Isthmus of Darien did not exist—so that the northern and southern portions of the New World were disconnected. Since the time when a connection was formed between the two continents, their faunas have, however, naturally tended to blend together, and hence at the present day, and during the Pleistocene period, the animals of South America are less sharply differentiated from those of the northern half of the continent than would have been the case had the Isthmus of Darien not been formed. It is further interesting to note that during the Tertiary period there appears to have been some kind of connection between the faunas of South America and Australia.

The country that has afforded us the most information with regard to the extinct fauna of South America is the Argentine Republic, which includes not only Buenos Ayres and the adjacent provinces forming Argentina proper, but likewise the whole of Patagonia. Confining our attention, in the first place, to the province of Buenos Ayres and some of the neighbouring districts, we may note that the greater part of this vast tract of country is one boundless level plain formed by an alluvial deposit of rich black mud brought down from the higher lands of the interior by the tributaries of the Rio de la Plata, and which constitutes the most extensive pasture-land in the world. Near Buenos Ayres and the valley of the Rio de la Plata this alluvial deposit, which in places alternates with sandy beds, is of immense thickness;* but further to the south it thins out rapidly. In some places in the neighbourhood of La Colina, about a hundred miles from Bahia Blanca, for instance, the black soil is not more than a couple of feet in thickness, and is underlain by a hard white calcareous deposit, locally known as "tosca," and much resembling some of the deposits formed by hot springs.† That the black alluvial deposit, which, from forming the whole of the pampas, or plain country, is known to geologists as the Pampean formation, is of fresh-water origin, is perfectly clear; and it is probable that it has been largely formed in marshes and swamps, one of its most striking features being the total absence of pebbles or stones. Indeed, throughout the country, except in the neighbourhood of the mountains, there is not a vestige of rock or stone to be seen, unless it be in the few places where the aforesaid "tosca" has been brought to the surface. In spite of its fresh-water origin, there is, however, evidence that portions of the Pampean formation have been submerged beneath the sea. For instance, in the neighbourhood of the city of La Plata there occurs a bed of marine shells overlying the alluvial mud; all the species of molluscs being now found living in the Bay of Monte Video. I have also observed a similar bed at Santa Lucia, in the Banda Oriental, at an elevation of about one hundred feet above the sea, which was overlain by a considerable thickness of sands, and the same deposit occurs far inland at the town of Parana. From these data it may be inferred that after the temporary subsidence of the pampas, during which the marine beds were deposited, there has been a considerable elevation (which is probably still going on) of the whole country; and that the whole of these movements have taken place at a very recent epoch indeed.

At the present day the Argentine pampas, with the exception of a few willows along the river courses, is practically destitute of trees (save where they have of late years been planted around the various settlements), and forms a boundless sea of grass, relieved here and there by tussocks of the tall pampas grass, or giant thistles, and adorned in spring with the scarlet verbena and other bright-hued flowers. Till the introduction of the countless herds of horses, cattle, and sheep, which now roam over its extent, this vast tract of country was tenanted by the guanaco, the pampas deer, the viscacha, and the rhea, which, with the exception of certain carnivores, were almost the only animals of any size to be found throughout its length and breadth.

The rich black alluvial mud of the pampas, which, as we have seen, is entirely of fresh-water origin, is, however, the tomb of thousands, if not millions, of the skeletons and bones of a host of extinct animals, which tell us that the country was once inhabited by a fauna stranger than that found in any other part of the world at any epoch of its history. While many of these extinct creatures were allied to the existing South American mammals, although of vastly greater bodily size, others, of equally gigantic dimensions, were utterly unlike all known animals, either living or extinct. As we intend to describe some of these extinct mammals in succeeding articles, we shall make but brief mention of them here. We may observe, however, that while the gigantic glyptodons were the representatives of the diminutive armadillos of to-day (although some of the latter flourished side by side with their huge cousins), the megathere, which rivalled an elephant in bulk, together with its allies the mylodons, were akin both to the sloths and the anteaters of Brazil, and as they were evidently terrestrial in habits they may be conveniently spoken of as ground sloths. From the structure of these latter animals, which were pretty evidently adapted to sit up on their massive haunches and tear down the branches of trees with their powerful front claws, we may infer that the physical features of this part of Argentina must have been very different from what they are at present, and that in place of continuous tracts of unbroken grassy plain there must have been large areas of forest land, as in Brazil at the present day. In these forest tracts may have wandered the two species of mastodons which were the contemporaries of the ground sloths; but the existence at the same time of several species of horses (some closely akin to living species, while others were markedly distinct) seems to point to the presence of grassy plains alternating with the forest tracts. The same is probably indicated by the numerous species allied to the guanaco, which flourished at the same time, and some of which attained the dimensions of a camel; while the various kinds of deer may also have inhabited the same regions. The gigantic hoofed mammal, known as the *Toxodon*, which had ever-growing teeth like those of a rodent, was, however, prob-

* Near Buenos Ayres it has been bored into for depths of fifty and ninety feet.

† At Buenos Ayres the alluvial deposit itself is called "tosca."

ably an inhabitant of swamps and marshes; while the still more extraordinary *Macrauchenia*, with its slender, camel-like neck, and long three-toed limbs, probably stalked over the plains, cropping here and there the foliage from some tree or copse. Rodents, nearly related to existing South American types, were likewise common; and there were also certain large carnivores, such as a species of sabre-toothed tiger, and a huge bear-like creature. With the exception of these carnivores, together with the guanacos, horses, deer, and elephants which are unknown in the older formations, and are therefore probably late immigrants from the north, all the animals of the Pampean formation are peculiar to South America. A further distinctive feature of this fauna is the large bodily size attained by so many of its representatives, this being especially the case with the glyptodons, mylodons, megatheres, guanacos, mastodons, macrauchenia, and toxodon, all of which would come under the designation of giant animals. In this respect the Pampean fauna corresponds with that of the Pleistocene period of Europe, with which it also agrees approximately in age, seeing that there is evidence of the contemporaneous existence of man with several of the extinct mammals.

In certain parts of the Pampean formation the remains of these animals occur in extraordinary profusion, and generally in a most perfect state of preservation. At times they are found sticking out from the perpendicular cliffs or *barancas* bordering the river-valleys, while many are met with in sinking wells or making other excavations. In well-digging, of course, only a portion of a skeleton is obtained in the case of a large animal, which is the cause of the imperfect condition of the majority of specimens in European museums, and it is only when excavations, like those during the construction of the docks at La Plata or Buenos Ayres, are made that entire skeletons are obtained, unless, indeed, special works are undertaken for the purpose of obtaining fossils. It does not, however, appear that the remains are at all evenly distributed through the Pampean, some localities being much richer than others, and among these Lujan (pronounced Luhán), near Buenos Ayres, being especially notable. Although the museum of the Royal College of Surgeons contains an entire skeleton of a megathere, together with the shell of a glyptodon, while the British Museum is the fortunate possessor of a complete specimen of a mylodon, the museums of Europe give us but a very poor idea of the number and beautiful preservation of these marvellous fossils. To gain any idea of the true state of the case it is necessary to visit (as I have recently had the opportunity of doing) the museums of Buenos Ayres and La Plata, and more especially the latter. There the visitor will be absolutely lost in astonishment at the long array of perfect mounted skeletons of numbers of these creatures, while the unmounted skeletons and isolated bones displayed in the wall-cases will convince him that I am not exaggerating when I speak of Argentina as a land of skeletons.

That the animals I have spoken of should have died off one after another through the long ages during which the Pampean mud was accumulating is in accordance with what we should expect to occur, while the perfection of their preservation is sufficiently accounted for by the nature of the deposit itself. The marvel, however, is in regard to the total disappearance of the whole of the larger forms and the reduction of the fauna of the pampas to its present condition, together with the concomitant loss of the forests. It is not that the country is unsuited at the present day to the existence of the larger types of animal life, as witness the countless herds of horses and cattle with which its plains are now covered, together with the luxuriance and rapidity with which many kinds of trees flourish when introduced. Neither, I think, can it be due to a glacial period (although there appears to be evidence of the prevalence of a cold period in Patagonia), since any glaciation of the pampas would have assuredly removed the greater part of the alluvial formation, besides having left indisputable evidence of its presence. Man, too, cannot be credited with the extinction of either the fauna or the flora. It has been suggested that the number of guanaco with which the country was overrun previous to European settlement may have caused the destruction of the forests; but we must remember that similar animals existed in greater variety during the Pampean period, while even if the disappearance of trees were due to their agency, this would have had no effect on plain-loving forms like horses. That the disappearance of the latter animals may have been due to the number of pumas is another suggestion; but it will be obvious that this could have had nothing to do with the destruction of gigantic creatures like the glyptodons and the megatheres. The problem is further complicated by the circumstance that the remains of many of these creatures occur in caverns in the interior of Brazil, where the climate is still, and probably always has been, tropical. It would seem, therefore, that we must be content to regard the depletion of the fauna and flora of Argentina as one of the unsolved problems of science.

So much space has been occupied by the foregoing survey of the Pampean fauna and the preliminary observations on the present condition of the country, that but little remains to devote to the older formations. At Parana, and also on the coast at Monte Hermoso, near Bahia Blanca, there occur, however, certain Tertiary deposits which are evidently somewhat older than the Pampean beds, although containing a closely-allied fauna. The most interesting feature connected with this formation (which may probably be correlated with the upper Pliocene of Europe) is that the mammals are for the most part of smaller size than their relatives of the Pampean; this being especially shown by the glyptodons, and by those ground sloths known as scelidotheres, which are near allies of the mylodons. When we reach the still older beds of Santa Cruz, in Patagonia, which are probably of Miocene age (although they have been correlated with the lower Eocene), we find not only this diminution in the size of the mammals still more marked, but we likewise notice the disappearance of all the northern forms, such as deer, horses, guanaco, and elephants, thus showing that we have reached the period when South America was disconnected from the northern half of the continent, and possessed an absolutely peculiar fauna. Instead of glyptodons with a shell of eight or ten feet in length, we meet with species in which the carapace did not measure more than a yard; while in place of mylodons bigger than a rhinoceros, we are confronted with a species not so large as a Highland sheep. The camel-like *Macrauchenia* was likewise represented by several much smaller allies, while the various species of *Nesodon*, which represented the gigantic *Toxodon* of the Pampean, were either small or moderate-sized animals. Somewhat curiously, there were, however, several kinds of gigantic flightless birds which are quite unknown in the higher beds, and appear to have been allied to the flying birds of the present day, instead of, as might have been expected, to the ostriches and rheas.

In subsequent articles we propose to enter into the consideration of the leading structural peculiarities of some of the most remarkable of the extinct mammals from the "Land of Skeletons."

XUM

BARK-BORING BEETLES.

By E. A. BUTLER.

ABOUT two hundred years ago, an English knight, Sir Matthew Dudley by name, planted in his grounds in Northamptonshire a number of young elm trees which were destined to have a more than passing interest. The misfortunes that befell them caused their memory to be perpetuated in the annals of British science by becoming enshrined in the *Philosophical Transactions* of the then recently formed Royal Society. All went well with the saplings for a time, but one dry summer one of the trees began to show symptoms of ill-health; its leaves became yellow and began to drop prematurely. As this particular tree stood higher than the rest and in shallower soil, Sir Matthew attributed its ill-health in some measure to the drought, and therefore caused the earth about its roots to be loosened, and two hogsheads of water, together with a quantity of manure, to be supplied to it, by which means the tree was for a time restored to a fairly prosperous condition. But Sir Matthew, being a close observer of nature, had noticed at the same time that on its bark there were numbers of "little black flyes of the beetle kind," and the removal of portions of the bark showed that these beetles had perforated it, and had made tunnelled excavations in its inner layers. He rightly conjectured that the beetles had something to do with the bad condition of the tree, though he regarded the insufficiency of moisture as the primary cause of its unfortunate condition. In endeavouring to link together cause and effect, and so to trace the proper sequence of events, he hit upon the idea that the drought had caused the sap of the tree to become thick and syrupy, and that the sap in this condition had formed an attractive bait for the beetles, which had then still further weakened the tree by their burrows.

The remedial measures adopted seem to have checked the evil for the time; but on the advent of another dry summer a few years afterwards, several of the trees again looked sickly, and particularly the one previously attacked. Examination showed that in them all the bark at its attachment to the tree was dry, and that there were "vast numbers of these little flyes, who had pierced the bark in multitudes of places." Having adopted the same remedies as before, Sir Matthew visited the trees again the next morning, and found that in one case sap was oozing from the bark through the holes pierced by the beetles, and that numbers of flies and wasps were congregated on the trunk, busily engaged in sucking up the sweet liquid. The removal of a little bark revealed plenty of moisture beneath, and showed that all the burrowing beetles had either gone or been drowned in the flood of sap which had inundated their burrows. This tree was ultimately saved, but the bark of many of the others, which seem to have been more damaged and further advanced in ill-health, remained dry, and the beetles still had things all their own way with them. Being naturally anxious as to the fate of his trees, Sir Matthew, to whom the beetles were evidently something quite new, carefully examined the bark and found that each beetle had made a "strait perpendicular channel from the entrance upwards, about two inches long, very little if at all bigger than just to move themselves straitforwards in"; for, he adds, "I observed they all of them, if disturbed, came out backwards." Further observation showed that "all along on each side the channel, as close the one to the other as they well could so as yet to be distinct, there were small channels running horizontally from it, in every one of which, at the extremity thereof, was a maggot, in size just the bigness of the small channels, very lively, whitish, and almost transparent." He at once recognized that these transverse channels must have had a different origin from that of the central perpendicular one (Fig. 1). While that was the work of the parent beetle, it was evident that the side branches were excavated by the maggots which were found at their terminations; for they were too narrow to admit of the entrance of the perfect insect. The eggs were evidently laid at regular intervals along the sides of the central gallery, and then the grubs hatched from them began at once to burrow in directions parallel to one another and at right angles to the mother's gallery, increasing the diameter of their tunnels as they advanced, to accommodate their own enlarged dimensions, and leaving the burrow behind them more or less blocked up with "very small particles which when dry become fine dust," the remnants of food and excrement.

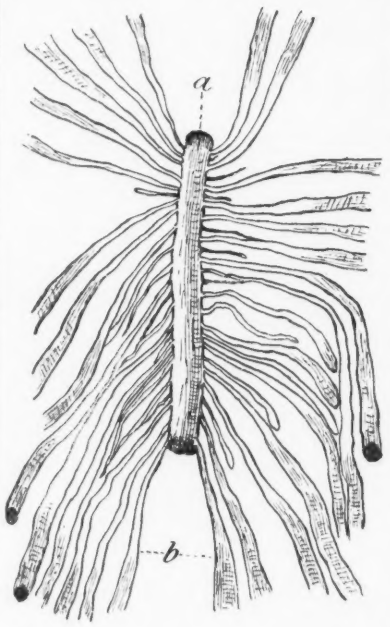


FIG. 1.—Bark burrowings, or "typograph" of *Scolytus destructor*. *a*, mother gallery; *b*, larval galleries.

But the whole life-history of the little pests was not yet fully disclosed, and time was necessary to permit of their proceeding with their metamorphoses. Accordingly we find further observations undertaken a few months later, both upon living trees and upon felled timber stored in the timber yard. The central channel was now found in all cases to contain the dead body of the mother beetle, while the side channels were empty, their occupants having escaped each through a neat circular hole in the bark at the end of its burrow. At the mouth of this hole, however, each had left, as evidence of its former presence, a "whitish, pretty tough skin, exactly the colour and size of the maggot." This, of course, was the chrysalis skin; so that it was evident that the larvæ had matured in their lateral burrows, had there become pupæ, and the perfect beetles produced from these had eaten their way into daylight, making a hole in the bark just large enough to admit of their crawling out. Such is the earliest English account of the life-history of that terribly destructive timber-pest, the little beetle now called *Scolytus destructor*, which was so ruinous in its effects on the above occasion that scarcely any of the trees were saved. In all essential details these observations have been repeatedly confirmed by subsequent entomologists, and few results of insect energy are now better known than these bark-sculptured family records, or "typographs," as they are called, each of which registers the total work of a mother and her entire youthful progeny till the latter have reached maturity, and have left the maternal home to push their own fortunes in the world.

The beetle which is responsible for this damage to elm trees is a stoutly and compactly-built shining insect, of somewhat cylindrical outline, averaging about one-fifth of an inch in length (Fig. 2). Its body is black, but the appendages thereto, such as legs, antennæ, and wing covers, have more or less of a reddish tinge. The head and thorax are very large and powerful, occupying between them half the length of the entire insect; and the biting jaws, upon the strength of which the success of the burrowing operations depends, are, of course, stout and very strongly made. The head is furnished above with a pretty clothing of yellowish hairs, which can easily be seen when the insect is viewed in profile, but are not very distinctly visible when it is looked at full-face. But the one feature by which especially it may be recognized and distinguished from all others of similar habits, except those few that belong to its own genus, is the curious shape of the abdomen. This looks as though a slice had been taken off it behind, since it slopes abruptly upwards from a short distance behind the last pair of legs to the ends of the wing covers (Fig. 3). Half a dozen species belonging to the genus *Scolytus* are known to inhabit Britain; they are all very much alike both in shape and coloration, but the fact that the various species attack different trees is a considerable aid towards their discrimination. The habits of all are similar, though not identical. The family to which *S. destructor* belongs contains about fifty British species, many of them minute, but all of strong build and cylindrical outline, as befits insects whose sole occupation consists of burrowing in bark. The economy of the group has been much studied by Dr. A. Chapman of Abergavenny, whose observations have been published in entomological periodicals, and from these some further particulars may now be given.

FIG. 2.—*Scolytus destructor*, or Elm-bark Beetle, magnified four diameters.

FIG. 3.—Side view of Elm-bark Beetle.

The female *S. destructor* makes preparations to lay her eggs early in June. She will attack preferably elm trees that have been felled during the previous winter, and Dr. Chapman avers that he has never met with traces of the insect in perfectly healthy growing trees, though, of course, it may be found commonly enough in those that are sickly. The female does not burrow straight inwards at the spot on which she alights; but, selecting one of the grooves in the bark, she gets to the bottom of this and often widens it for some distance, and then enters the bark itself. The real opening to the tunnel, therefore, lies at some distance from the commencement of the burrows, and hence these entrance orifices are not so easily seen as those by which the beetles make their exit, since these latter run straight outwards from the ends of the galleries and appear like holes carefully made with a bradawl. The female commences her labours by herself, before she has received the overtures of a partner, who, in fact, does not put in an appearance till she has already started her internal burrow. But when she has got her burrow well in hand, the expected suitor arrives, or, if he do not, the labour must be stopped to wait for him, as no further progress can be made till he has come. He appears rarely to enter the burrow, the toil of excavation being left entirely to his partner. Should the female be so unfortunate as not to be discovered by any member of the opposite sex, the burrow begun in trust will have to be left unfinished and its purpose will never be realized, as no progeny will ever occupy it. But if all goes well, the continuation of the burrow can proceed. It is made straight up the trunk for about three inches, and as it is pushed forward eggs are deposited at regular intervals on each side, each in a little depression close to the wood. About a hundred are thus fixed in double row along the tunnel; they are glutinous as laid, and become coated with a rather thick layer of "frass," as the powdery refuse in the burrows is termed.

Something like three weeks will have been consumed in the construction and peopling of the central channel, but before the end of that time the eggs first laid have hatched, and the little white footless maggots have begun to make their transverse burrows, side by side, though still not in actual communication, and yet so close as only to leave a very narrow wall between. These burrows are in the softest part of the bark, the cambium layer and adjacent soft tissues being devoured, though but very little impression is made on the wood beneath. When the tree is stripped, one can see that while the bark itself contains the greater part of each burrow, one side of each has slightly encroached on the wood, so that the bared trunk shows in feeble outline a pattern corresponding to the typograph which appears deeply cut in intaglio in the bark.

In about a month's time the larvæ will be full-fed; most of them will then burrow for about half an inch straight into the wood at the end of their burrows, and then excavate a little chamber, which is to be the winter quarters. Where this communicates with the larval burrow a plug of frass is placed to block up the entrance—a wise precaution, for otherwise, if the bark should fall off during the winter, as the damage it has received might well cause it to do, they would be exposed, not only to the severity of the weather, but also to the attacks of insectivorous birds; while if the bark remain on, they will then be doubly protected. Some of the more enterprising ones, however, do not behave thus, but hurry through their changes and come out as perfect beetles in August, piercing to the outside a straight circular burrow at the end of their gallery. What becomes of these individuals is not yet very clear. Of course, those that have burrowed into the wood escape next spring in the same way as their predecessors. We thus notice that there are two sets of cylindrical holes made in the bark of the tree—the entrance holes of the parent females, partially filled up and not very conspicuous; and the exit holes of both males and females of the young brood, which are open and easily seen. There are also two distinct classes of galleries—the vertical one made and occupied by the mother of the family only, and serving as her mortuary chamber when she expires at the close of her labours; and the lateral galleries made and occupied solely by the larvæ. Thus the whole typograph contains, as we said above, the family history of one complete generation, carved in wood, and left as a permanent memorial long after the generation whose adventures it chronicles has passed away.

The bark of ash trees is often found to be channelled in a somewhat similar way; but this is easily seen to be the work of a different insect, as there are some striking differences in the plan of the typograph. We still have the central channel and the host of side channels running at right angles to it, but the actual directions are exactly reversed; the central channel is now horizontal, and the side channels are perpendicular, running above and below the transverse main trunk. Moreover, the main trunk is composed of two arms which lie nearly in the same straight line, but diverge right and left from an exceedingly short perpendicular stem, the whole forming a figure something like a T of greatly exaggerated breadth and diminished height (Fig. 4). The beetle whose family record is preserved in this form is called *Hylesinus fraxini*. It is a

smaller and much duller insect than the preceding, and more regularly cylindrical, without the curiously cut-off abdomen so characteristic of *Scolytus*. The economy of

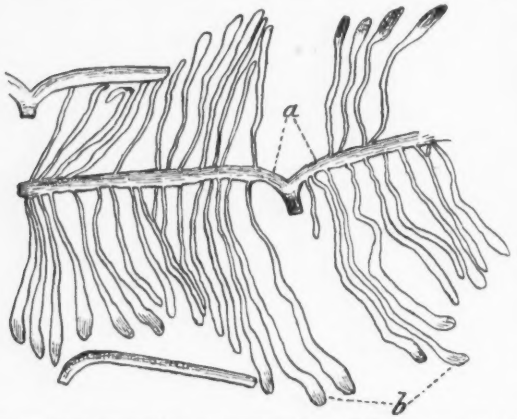


FIG. 4.—Bark burrowings, or "typograph" of *Hylesinus fraxini*, Ash-bark Beetle. *a*, mother gallery; *b*, larval galleries. (To avoid confusion, the larval galleries of one system only have been shown.)

this insect is very similar to that of *S. destructor*, but the male takes a somewhat more practical interest in the serious business of life. Both beetles may be found in the burrows during the course of construction, frequently one in each branch, and of course it is an obvious suggestion that one of these branches is made by the male, and the other by his partner; but it is difficult to say how much truth there is in such a suggestion, and it seems not unlikely that even in this case the female does the greater part of the work, though apparently her mate does something to assist. Both beetles also usually die in the burrow, and their corpses may sometimes be found still lying there several years after death. Damp and mildew, however, in time do their work, and the corpses decay and disappear.

The other members of this group are more or less like those already described, and the cylindrical form, short legs, and large thorax will usually enable them to be recognized. They attack a variety of trees, some devoting their attentions to the trunk, others to the branches and smaller twigs. Elm, ash, oak, beech, birch, hazel and hornbeam are all more or less liable to attack, and fruit trees, such as apple, pear, plum, cherry and apricot, are by no means exempt. A large proportion are devoted to the different species of firs and pines, and some attack shrubs, such as ivy, furze and broom. But wherever they are found, they always leave their signature behind, in the typograph on the inner surface of the bark, and its fainter reproduction which is seen on the wood when the bark is removed. Until an affected tree is stripped, the evidences of their presence, apart from any sickly appearance the tree may present, are not striking, and the slight indications outside can give no notion of the vast extent of the damage which may lie concealed within. These little beetles must be carefully distinguished from another set of wood-borers, some of which are not unlike them in both shape and general appearance, but which do not leave a typograph behind them, since they burrow into the substance of the wood itself, instead of confining themselves to the bark. Belonging to this latter group is the troublesome household pest which makes furniture "worm-eaten" (*Anobium domesticum*). Wood-borers such as this are distinct from the bark-borers, not only in habits, but in structure too, and are therefore, for systematic purposes, placed in a different section of the beetle order.

There are two somewhat opposing aspects in which these bark-boring beetles may be regarded. In the first place, in so far as they attack living trees, they cannot be regarded as otherwise than terribly destructive. Though the solid timber, it is true, is scarcely injured at all, and the actual amount of material destroyed bears a ridiculously small proportion to the total bulk of the tree, yet the death of the tree is ensured by the fact that it is just the most vital part that is attacked. The centre of the life and growth of the tree lies in the layers which intervene between the hard bark on the outside and the hard wood on the inside; it is here only that the cells of which the tree is composed still remain soft and retain their power of self-multiplication, and therefore, so long as this particular part of the tree is intact, its functions can go on more or less regularly, and its life can be maintained. But when once these layers are tampered with, the health of the tree suffers, and the gradual removal of the growing and multiplying tissue is necessarily followed by the death of the tree, though the solid timber is still available for use. In consequence of their enormous numbers, some of the smaller species are in this respect even more destructive than the larger ones.

There is, however, another light in which the ravages of these insects may be regarded. In many cases, no doubt, they merely accelerate the destruction of trees which from other causes are passing into decay, while some seem to prefer fallen timber to that which is growing; and it is in this latter respect that they may to some extent be regarded as useful agents in the economy of nature. In the interests of surrounding vegetation, it is important that fallen trunks should be removed as speedily as possible, and many are the natural agencies that combine to bring about such a result. Amongst these, damp is of course one of the most important, as it provides the conditions necessary for the growth of fungi, which, growing on the wood, derive their nourishment from it, and accelerate its dissolution. But much of the material of which the bark is composed is of the nature of cork, and is impervious to moisture, so that as long as the bark remains on the tree the fungi have not a fair chance. To meet this difficulty, there come in these bark-feeding beetles, which speedily loosen the bark and cause it to crack so that it soon falls off, and then the solid wood is exposed to all sorts of destructive agencies—whether physical such as damp, vegetable such as fungi, or animal such as wood-boring insects—and between them they make short work of the trunk. In virgin forests, no doubt, such insects as these are of material assistance in promoting the growth of new vegetation, by aiding in the removal of the old. In countries like our own, however, which are well under the control of man, such a function is, no doubt, scarcely needed, and to us these bark-boring beetles seldom appear in any other light than as a nuisance.

PERIODICAL COMETS DUE DURING THE REMAINDER OF THE PRESENT CENTURY.

By W. T. LYNN, B.A., F.R.A.S.

IT can scarcely be said that any one of the known periodic comets is due during the present year. The late M. Tempel was the first discoverer of no fewer than three comets which were calculated to be moving in orbits of short period; but the periodicity of one of these, which was discovered in the month of November, 1869, was not recognized until after its rediscovery by Prof. Swift in 1880 (an unobserved return must have taken place in 1875), in consequence of which

it is usual to call it Swift's comet. The body known as Tempel's first periodical comet was discovered by him at Marseilles on the 3rd of April, 1867; the period was found to be about six years, and it duly returned in 1873 and 1879, but has not since been seen. His second periodical comet, which was discovered at Milan on the 3rd of July, 1873, was calculated to have a period about five and a quarter years in duration. It was observed again in 1878, but not afterwards, so that it seems rash to speak of a return as due in the present year, though three times the length of a period will, in the spring, have elapsed since 1878, when the comet passed its perihelion on the 19th of July.

But we now have to refer to a comet which has returned so regularly during more than a century, that it has come to be looked upon as a friend whose periodical visits may be confidently expected. I now allude to Encke's comet, which, first discovered by Méchain in 1786, only acquired its name after the return of 1818, when its orbit was accurately determined by the illustrious Seeberg, an astronomer, who became director of the Berlin Observatory in 1825. He found that the period was much shorter than that of any other known comet, and that its duration amounted to only twelve hundred and twelve days, or about three and one-third years. Extending his investigations, he showed that this was slightly diminishing by a little more than a tenth of a day at each return, and suggested, as the probable cause of this, the action of a resisting medium in the inner portion of the comet's orbit (when in perihelion it passes within the orbit of Mercury) checking the tangential motion of the comet and causing it to be drawn somewhat nearer to the sun, so as to shorten its length of revolution, and therefore its period. The comet has been observed in some part of the world at every return since 1818; and whilst Encke lived he was able to show that the above effect continued to appear and with the same rate of progress, confirming the truth of his theory as to its cause. Nor was it easy to take any other view of the phenomenon, with such a *vera causa* apparently fully able to explain it. But after this had gone on for about fifty years from the time that Encke first called attention to it, Von Asten and Backlund, who had followed up his investigations, found that in 1868 the observed diminution of the length of period dwindled to one-half its original amount, and it has apparently continued to go on at this diminished rate ever since. It is to be hoped that more light will, before long, be thrown upon this remarkable circumstance, which imparts additional interest to further observations of Encke's comet. It was last in perihelion on the 18th of October, 1891, and the next return to that position will be due on the 10th of February, 1895.

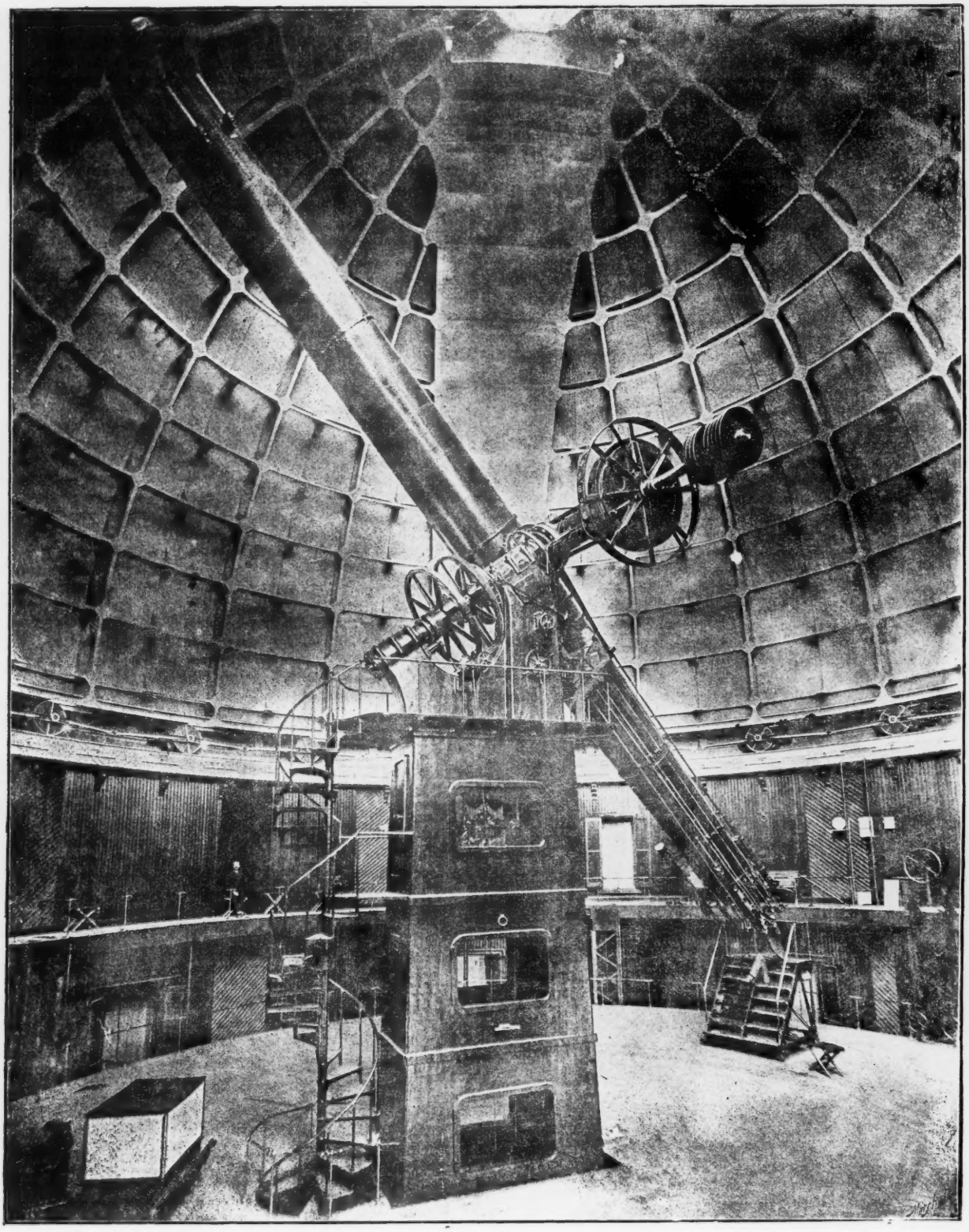
A passing reference may here be made to Brorsen's comet, which was discovered at Kiel in 1846, found to have a period of about five and a half years, and was observed at several subsequent returns, but the last of these was in 1879. As we cannot venture to predict its return in 1895, we will pass on to 1896, in which year two periodical comets will be due. One of these is known as Faye's, having been discovered by that astronomer at Paris on the 22nd of November, 1843. Le Verrier calculated its orbit, and found that the length of its period was about seven and a half years; it was duly observed at every subsequent return, passing its perihelion on the last occasion on the 20th of August, 1888, so that another return may be expected in 1896. The other comet due in that year was discovered by Mr. Brooks, at the Smith Observatory, Geneva, N.Y., on the 6th of July, 1889; great interest was imparted to it by Mr. S. C. Chandler's investigations, which showed that its period when under observation was about seven years, but that the orbit had been much disturbed by a near approach to the planet Jupiter in 1886, and that the comet was very probably identical with Lexell's comet of 1770, which had not (in consequence also of Jovian attractions) been seen since the year of its discovery, though calculated to have a period of only about five and a half years. However plausible this view seemed, later investigations made by Dr. Lane Poor have (as was pointed out by the writer in an article contributed to the number of KNOWLEDGE for last November) thrown very considerable doubt upon it, which can only be cleared up by the results of the observations which it is to be hoped will be obtained in 1896.

In 1897 also two periodical comets will be due. The first of these was discovered by D'Arrest at Leipzig in 1851, found to have an elliptic orbit with a period of about six and a half years, observed in 1857 and at every subsequent return except that due in 1884 (when it was unfavourably placed), passing its perihelion on the last occasion on the 16th of September, 1890, so that another return will be due early in 1897. The other is Swift's comet, to which we have already alluded, and which since it acquired its name in 1880 has only been seen at the last return in 1891, having been unfavourably placed for observation in 1886. But, as already remarked, it was first discovered by Tempel in 1869, and another return may be expected early in 1897.

In the summer of 1898 a return will be due of the comet known as Winnecke's, since he detected it in 1858, and showed that it was identical with one discovered by Pons so far back as 1819, with a period of about five and a half years; it escaped observation in 1863 (as it afterwards did in 1880), but was observed near perihelion in 1869, 1875, 1886, and 1892, so that another return may be expected in 1898. About the same time a return of Encke's comet will again be due; and in the autumn of the same year a fine comet, which was discovered by Dr. Max Wolf of Heidelberg on the 17th of September, 1884, found to have a period of nearly seven years, and well observed at the last return in 1891.

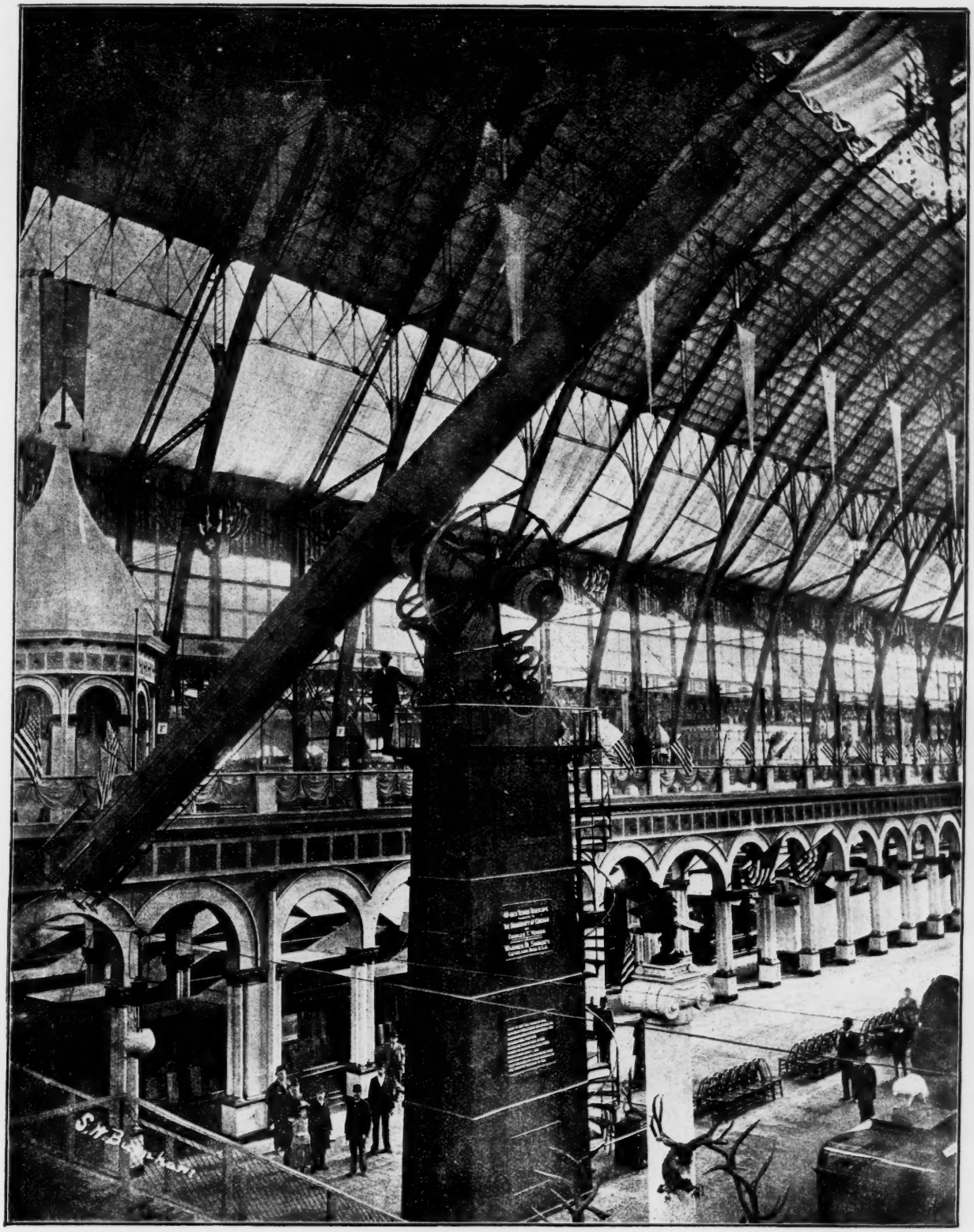
In the last year of the present century a return of Tuttle's comet will be due. This body occupies a unique position in having a period of somewhat less than fourteen years. It acquired its name after Mr. Tuttle had detected it in 1858, but the calculations made of its orbit showed that it was identical with one discovered by Méchain (also the first discoverer, as we have seen, of Encke's comet four years before) in 1790, and it has since been observed at returns in 1871 and 1885, passing its perihelion on the 11th of September in the latter year. The interesting comet discovered by Mr. Holmes at Islington in November, 1892, will also be due in 1899, as its period is less than seven years. Later in the same year another return may be expected of Mr. Finlay's comet, which has a period of about six and a half years, and has, since its discovery by Mr. Finlay in 1886, been observed at the return which took place in the summer of last year (1893). But, in addition to all these, a very interesting cometary visitor will be eagerly looked for in 1899; we mean the one moving in the same orbit as the Leonids, or mid-November meteors. The comet has only hitherto been seen in the winter of 1865, when Tempel discovered it on the 19th of December, and it passed its perihelion on the 11th of January, 1866. Its period, like that of the meteoroids, is about thirty-three and a quarter years; and it is the comet of shortest period which moves in a retrograde direction, all those of shorter periods revolving round the sun in the same general direction as the planets.

XUM



The Lick Thirty-six-inch Refracting Telescope.

From a photograph taken by Mr. BURNHAM within the Dome of the Lick Observatory. Focus, 57 feet 10 inches.



The Mounting of the Forty-inch Refracting Telescope, presented by Mr. Yerkes to the University of Chicago.

From a photograph by Mr. BURNHAM, taken in the Chicago Exhibition. Focal length, nearly 64 feet.

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THE GIANT REFRACTING TELESCOPES OF AMERICA.

By A. C. RANYARD.

WE live in an age when "records" are almost daily being broken, but it is now almost half a century since the largest telescope yet turned to the heavens was completed by the father of the present Earl of Rosse. He cast his gigantic mirror, six feet in diameter, on the 13th April, 1842, and after nearly three years' labour it was mounted at Parsonstown in February, 1845. This great telescope, contained in a tube seven feet in diameter, with a focal length of fifty-four feet, still remains the greatest light-grasping instrument which has been turned to the stars; but its defining powers are very inferior to many smaller instruments which have since been made.

It was not till 1846, a year after the completion of the Rosse reflector, that refracting telescopes reached a diameter of fifteen inches. In that year, Merz and Mahler, of Munich, completed two fifteen-inch refractors, one for Harvard College Observatory, and the other for Pulkowa. These comparatively small telescopes quickly showed themselves to be superior in defining power to the great Rosse telescope. With the Harvard telescope Prof. W. C. Bond, in 1848, discovered Hyperion, the eighth satellite of Saturn, a discovery which was almost simultaneously made by Mr. Lassell in England, with a reflector of two feet aperture of excellent defining powers. In 1850 Bond also discovered with the Harvard fifteen-inch refractor the crape ring of Saturn, a discovery which was likewise very nearly simultaneously made in England by Dawes, with a refracting telescope of smaller aperture.

For about fifteen years the limit of aperture for refracting telescopes attained by Merz was not exceeded; then America took the lead, and in 1860 Alvan Clark, the father of the present instrument maker, made an eighteen and a half inch refractor, with which he discovered the companion to Sirius. For ten years this remained the largest refractor in existence; then England took the lead with a twenty-five-inch object glass made by Cooke, of York, for Mr. R. S. Newhall, of Gateshead, in 1870. Three years later, Messrs. Alvan Clark and Son made the twenty-six-inch refractor for the Washington Observatory, with which the satellites of Mars were discovered. Then followed two thirty-inch refractors, one made by the Brothers Henry, of Paris, for the Nice Observatory, and the other by Messrs. Alvan Clark and Son for the Russian Imperial Observatory at Pulkowa; and, lastly, the thirty-six-inch refractor made by Alvan Clark and Son for the Lick Observatory. The optical excellence of the great Lick telescope is vouched for by the work done with it by Mr. Burnham on close double stars, and by the discovery made with it by Mr. Barnard of the fifth satellite of Jupiter.

American astronomers have always shown a preference for refracting telescopes; with the exception of the late Dr. Henry Draper, who figured and mounted for himself a twenty-eight-inch silver on glass reflector, no American has constructed a reflecting telescope of any considerable size. Their scientific enthusiasm has restrained them from merely endeavouring to outdo the Earl of Rosse in the construction of instruments of great light-grasping power, and has turned their inventive genius to the difficult problems involved in the evolution and growth of the achromatic telescope. The French still retain the lead as the makers of large discs of optical glass from which the large refractors are made. The disc of flint glass from which the flint lens of the object glass of the Lick telescope was made took three years to manufacture. It was repeatedly tested and the defective parts were cut out and replaced by fresh optical glass which was welded to the original mass by pressure at a white heat; the disc was then slowly allowed to cool, and again tested, and any new defects found were again operated upon.

The difficulty of manufacturing large homogeneous discs of optical glass is, at present, the chief obstacle in the way of increasing the size of achromatic telescopes. Such large masses of glass are very heavy, and when supported by their edges in a cell their weight causes the lenses to bend; but a small amount of flexure causes less disturbance in the image thrown by a lens than a similar amount of bending of a speculum would cause in the image thrown by a speculum.

For if a reflecting surface is shifted through a small angle the reflected ray is shifted through double the angle, while a similar change in the position of a refracting surface causes only a very slight shift in the direction of the refracted ray. Thus it happens that though lenses can only be supported by their edges, while specula can be supported at their backs as well as at their edges, the small distortions due to the weight of material cause a greater disturbance in the image thrown by a large reflector than in the image thrown by a large refractor; otherwise large reflectors would be vastly superior instruments to large refractors, for with reflectors light of all colours is brought to the same focus, while the difficulty of achromatizing a lens increases with its diameter, and the larger a refractor the greater must be the ratio of focal length to aperture in order to obtain the same degree of achromatism. Thus the focal length of the Lick telescope is fifty-seven feet ten inches, to an aperture of thirty-six inches, and the Yerkes telescope will have an aperture of forty inches, and a focal length of nearly sixty-four feet, or a ratio rather less than one to nineteen instead of one to twelve as with small achromatics.

With every increase in focal length all the mechanical difficulties connected with the mounting and the size of dome and shutter increase as the cube of the focal length, for the weight of all the parts increases as the cube of their lineal dimensions. Consequently every effort is made to keep down the focal length of such large telescopes, so far as it reasonably can be kept down consistently with a sufficient degree of achromatization for defining purposes. An observer who looks through one of these large refracting telescopes for the first time is greatly struck with the amount of outstanding colour around the stars. The violet end of the spectrum is generally left outstanding, and the star appears bathed in a field of violet light, which, however, interferes very little with the sharpness of vision.

Our second plate shows the mounting of the great telescope which Mr. Charles T. Yerkes is presenting to the University of Chicago. It is dwarfed by the size of the Exhibition building, but if the size of the figures standing in the neighbourhood is compared with the telescope it will be seen that it is much larger than the Lick telescope, which at first sight looks larger.

The lenses for the Yerkes telescope are already roughly figured, but they are not finished. Mr. Alvan Clark was present at the last meeting of the Astronomical Society, and gave the Fellows an account of the way in which the work is proceeding. I have also received some additional information from Prof. Hale, who is at present in Berlin.

The flint lens is very white. It is a particularly fine piece of glass and weighs about three hundred pounds. Its thickness is about one and a half inches at the centre and two and three-quarter inches near the circumference.

The crown lens weighs about two hundred pounds. It

is about three inches thick at the centre and seven-eighths of an inch at the circumference.

The flint lens corrects the crown so that the minimum focus will be at about wave-length 561.

For photographic work with the spectroscope in the blue, violet and ultra-violet, a small lens will be used near the focus for correcting the chromatic aberration at the centre of the field only. Dr. Huggins has used such a lens with his visual objective, and succeeds in bringing the spectrum from F to H satisfactorily to focus. The spectroscope thus remains in its ordinary position, while in the Lick telescope, when the photographic correcting lens is placed over the objective, the focus is changed from fifty-seven feet ten inches to forty-seven feet ten inches, and in practice the spectroscope is not used when the corrector is in place. The principal advantages of the small correcting lens are: (1) small loss of light from absorption; (2) no change in the principal focal plane; (3) convenience in handling; (4) its weight is so small that no change in the balancing of the telescope is necessary on adding the corrector. Its chief disadvantage is that a small lens so near the focus only gives a small field of view, but this is immaterial for stellar spectroscopy.

The telescope, dome and shutter will be moved by electric motors controlled by buttons on a key-board at the eye end, but the motions can also be directed from the balcony at the head of the telescope, and from a table in the observing room.

Hydraulic rams, which can also be controlled electrically in the same manner, will lift or lower the whole floor of the Observatory, so that no observing ladders will be necessary.

The clamps of the telescope are operated by powerful electro-magnets, and it has been found that the instrument can be instantly clamped much more firmly than in a longer period by hand.

The driving clock, which weighs about one and a half tons, is never allowed to run down, but when the weight has descended to a certain point it automatically starts an electro-motor, which winds the clock up again.

All the motions, clamps, &c., can be operated in the ordinary way by hand.

The dome for the Yerkes telescope will be eighty feet in diameter, and the observing shutter will be fifteen feet wide.

The tube for the Yerkes telescope is forty-two inches in diameter at the objective end, fifty-two inches at the centre, and thirty-eight inches at the eye end. The sheet steel forming the tube varies from 7·32 inches in thickness at the centre to 1·8 inches at the ends. The total weight of the tube is six tons.

The declination axis carrying the tube is of forged steel, twelve inches in diameter, and twelve feet long; its weight being one and a half tons. It runs in segmental bearings in the declination sleeve, which weighs four tons.

The polar axis carrying the whole system is of forged steel, fifteen inches in diameter at the upper bearing and twelve inches at the lower bearing, and weighs three and a half tons.

The great weight of the bearings on these axes is almost wholly relieved, and the resistance changed from sliding to rolling friction, by means of three bracelets or live rings of steel rolls. One of these encircles the declination axis near the tube, and one is placed above each bearing on the polar axis. These anti-friction live rings are pressed against the axes by means of adjustable springs.

The pier or column is made in five sections. The base section weighs about eighteen tons, the other sections weigh about five and a half tons each. The height of the column from base to top is thirty-one feet four inches. Each section of the pier is above six and a half feet high. The head of the pier is of cast iron, in one piece, and weighs five and a half tons. The total weight of the pier and head is about forty-five tons. The height from the base of the pier to the centre of motion is forty-three feet six inches, and the total weight of the whole telescope and mounting will be about seventy-five tons.

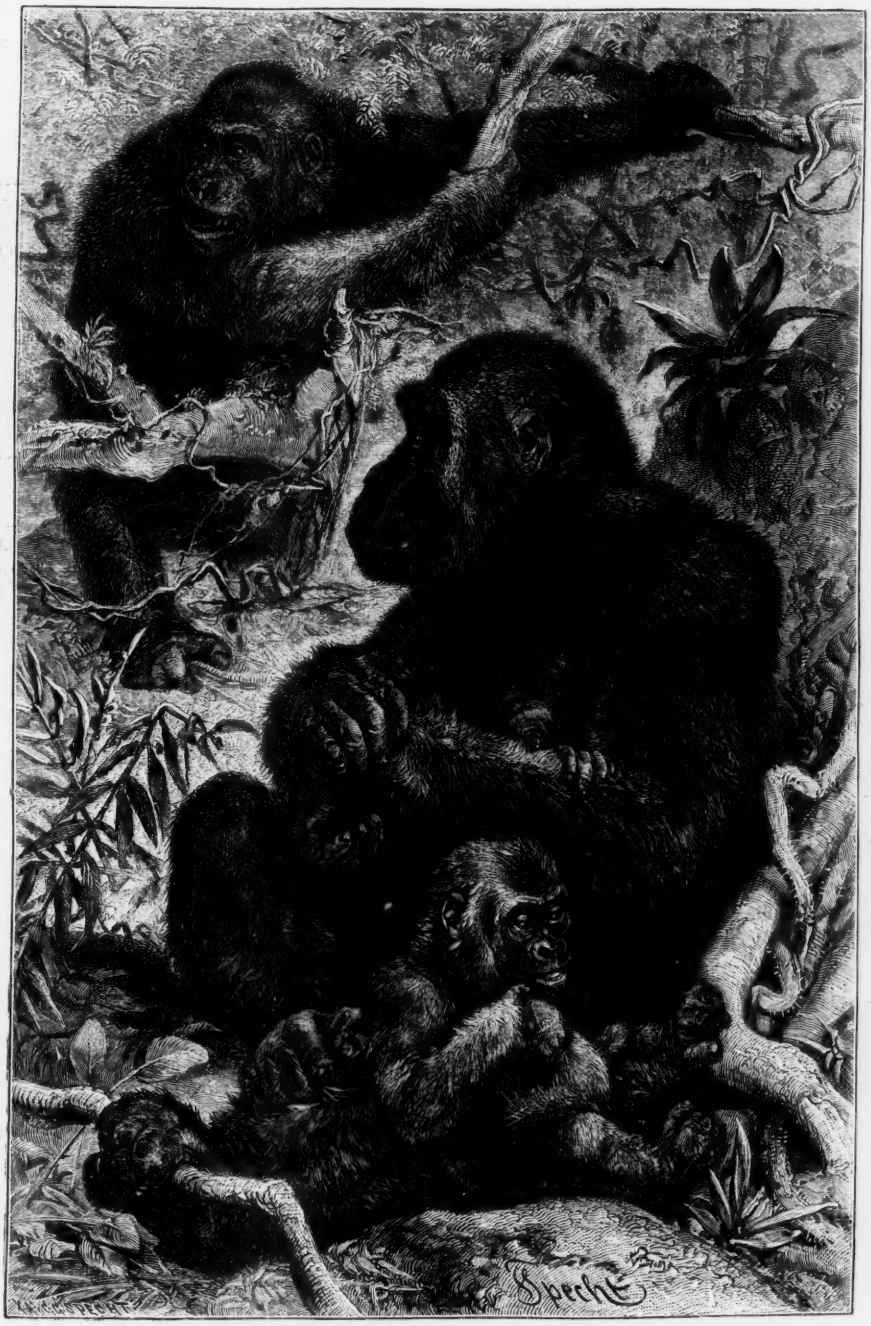
Mr. Yerkes has purchased about fifty acres of land on the borders of Lake Geneva, Wisconsin, as a site for the new Observatory. The plans for the building are now being prepared and its construction will be commenced in the spring. The Observatory will be about one hundred and fifty feet above the lake, and at a distance of about seventy-five miles from Chicago. Prof. Hale has been appointed Director of the Observatory, and Mr. Burnham has recently been appointed Professor of Practical Astronomy in the University of Chicago and Astronomer in the Yerkes Observatory. No other members of the staff have as yet been appointed. With two such exceptionally able astronomers, one may confidently look forward to many important discoveries being made on the borders of Lake Geneva.

The size of KNOWLEDGE will, from the commencement of this year, be increased by the addition of four pages.

NOTATION FOR THE LINES OF THE HYDROGEN SPECTRUM.—Prof. H. C. Vogel has recently suggested (*Astr. Nach.* 3198) a slight change in the notation for the lines of the hydrogen spectrum, which will do away with a present cause of confusion. The four lines in the visible portion of the spectrum, C, F, "near G," and *h*, have long been known as Hα, Hβ, Hγ, and Hδ. When Dr. Huggins discovered the series of hydrogen lines in the ultra-violet region of the spectra of white stars, he distinguished these by the letters of the Greek alphabet, beginning with the line at λ 3889 as α. From the first it was extremely probable that these lines were due to hydrogen, but now that their origin is definitely established, the occurrence of a double α and β, &c., in the series is a decided inconvenience. Prof. Vogel therefore proposes, and Dr. Huggins supports his proposition, to call the fifth hydrogen line, formerly known as H or H_1, H_ϵ; and the first line of the Huggins series Hζ. All the other lines of the Huggins series will thus be advanced five steps in the Greek alphabet, and the line λ 3704, formerly known as ι, will now be Hξ.

A restoration of *Coryphodon*, one of those large mammals that appear so suddenly in the lower Tertiary rocks, by Prof. Marsh, appeared in the *Geological Magazine* for November. He controverts entirely Osborn's opinion that this animal walked upon the tips of its toes with its fore limbs after the fashion of the elephant, while with its hind limbs it was plantigrade after the fashion of a bear. Perhaps the most striking characteristic of these early mammals is the minute brain, which is proportionately even less than that of many reptiles and amphibia. The cast of the brain case, both of this animal and its near relative the *Deinoceras*, show a ratio of brain to skull less even than that obtaining in the frog.

The *Lancet* bacteriologists could scarcely be expected to leave our ice alone during the terrible heat wave of last summer. In the laboratory cultures from 400 to 700 colonies of bacteria per cubic centimetre of melted Norwegian ice were obtained, and with this distressing fact they inoculated the press and produced a mild epidemic of paragraphs. The advice tendered the public was to use ice from distilled or sterilized water, but where is it to be obtained?



Gorillas at Home.

Notices of Books.

The Royal Natural History. Edited by Richard Lydekker, B.A., F.G.S., &c. Parts I. and II. (London : F. Warne & Co.) If the two parts of this book which have been already published are fair samples of the thirty-six in which it is to be completed, the complete work will certainly be the handsomest and most readable book on general zoology which has as yet appeared. It does high credit to all who have had a hand in its production, being not only full of information conveyed in simple and more comprehensible language than zoologists ordinarily employ, but it is beautifully illustrated with wood-cuts and coloured pictures that exhibit a high degree of artistic merit controlled by scientific accuracy. In the two parts before us we have the first instalment of Mr. Lydekker's treatise on mammals, which is to extend over fifteen monthly issues, and is to be followed by an important section devoted to birds, to which Dr. Bowdler Sharpe, Mr. Ogilvie Grant and Mr. Macpherson are to contribute largely; the remaining twelve parts will continue the survey of the descending series of forms of life to the lowest of the invertebrates. Part I. has a capital introductory chapter on mammalian characteristics, and the attack on the constituent orders is opened with an exhaustive survey of the Primates, which are reviewed *seriatim* from the anthropoid apes to the colobine monkeys; the subsequent groups down to the marmosets occupying the second part. Every genus is described in full, over a hundred and thirty representative species coming under notice, most of them at considerable length, with much that is interesting as to their distribution, habits and history; and this information is not of the obsolete, hearsay kind frequently thought good enough for repetition in popular works on zoology, which contain much that the student has subsequently to unlearn. The chief place amongst the many excellent features of this work must be given to the broad and powerful treatment of the palæontological side of the subject, which, as our readers already know, Mr. Lydekker is specially fitted to deal with. Every species is compared with its nearest allies or direct representatives as revealed in the record of the rocks. The illustrations are very numerous and cannot be too warmly praised. The first, which we are permitted to reproduce, represents a gorilla family.

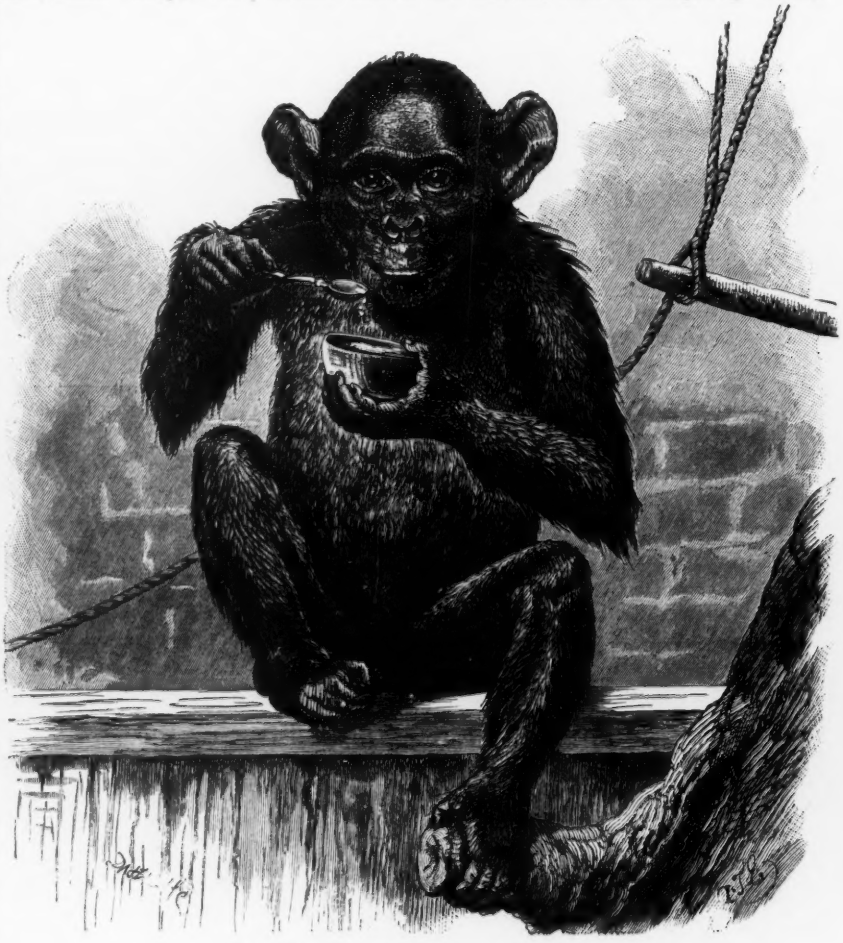
Mr. Lydekker's description of the larger anthropoid apes will be found extremely interesting. He reminds us that a full-grown male gorilla, if standing in a perfectly upright position, will generally measure rather more than six feet in height; and since his body is much more bulky, and his limbs are longer than those of man, he is considerably the largest representative of the Primates. Gorillas habitually live in small families, having young ones of various ages with them. They live a wandering life and do not frequent the same sleeping-place for more than three or four consecutive nights, travelling considerable distances through the dense forests in search of fresh supplies of suitable food.

Although in appearance male gorillas are somewhat unwieldy creatures, yet they are most active and indefatigable climbers, and are said to ascend to the very tops of the forest trees, where they pass from tree to tree almost as readily as the far lighter spider-monkeys of Brazil. They are also capable of taking leaps from great heights to the ground without damage to themselves. Herr von Koppenfels says that he saw an adult spring from a tree at a height of some thirty or forty feet, and on alighting disappear into the scrub.

Of all the large man-like apes, those which on the whole make the nearest approach in bodily structure to man are the chimpanzees of western and central equatorial Africa. In the autumn of 1883 a young chimpanzee, called "Sally," was purchased by the Zoological Society of London. Mr. Bartlett, the superintendent of the society's gardens, soon recognized that she was very different from the true or common chimpanzee, and he considered that the animal was probably one of the black-faced chimpanzees, termed by Du Chaillu "bald chimpanzees." The ordinary chimpanzee has a white or pale flesh-coloured face, hands, and feet, and is a vegetable feeder, but "Sally" showed a disposition to live upon animal food. Mr. Bartlett says that soon after her arrival he found that she would kill and eat small birds; seizing them by the neck, she would bite off the head and eat the bird—skin, feathers and all. For some months she killed and ate a small pigeon every night, but after a time her keepers supplied her with cooked mutton and beef tea, upon which she did very well. She was an expert rat-catcher, and caught and killed many rats that entered her cage during the night.

Mr. Bartlett soon recognized that her intelligence was far above that of the ordinary chimpanzee; she quickly recognized those who had once made her acquaintance, and paid marked attention to men of colour by uttering a loud cry—*bun, bun, bun*. Dr. J. G. Romanes made her acquaintance and endeavoured to test her mental powers. His account of her was written in 1889, after she had been nearly six years in the Zoological Gardens. He compared the intelligence of "Sally" to that of a child a few months before emerging from the period of infancy, and considered that it was far higher than that of any other mammal, with the exception of man.

In spite, however, of this relatively high degree of intelligence, the creature's power of making vocal replies to her keepers, or those with whom she was brought into contact, were of the most limited kind. Such replies were restricted to three peculiar grunting noises. One of these indicated assent or affirmation; another, of very similar intonation, denoted refusal or distrust; while the third, of totally different intonation, was used to express thanks or recognition of favours. In disposition, says Dr. Romanes, "Sally" was like many of her sex, apt to be capricious and uncertain, although on the whole she was good-humoured and fond of her keepers, with whom she was never tired of a kind of bantering play, which was kept up at intervals almost continually. By singing in a peculiar kind of monotone in imitation of her own utterances, her keepers were usually able to induce her to go through a series of remarkable actions, the meanings of which were not very apparent. First she would shoot out her lips into a tubular form, uttering at the same time a weird kind of howling note, interrupted at regular intervals. The pauses would, however, gradually become shorter and shorter, while the sing-song became



"SALLY," THE BLACK-FACED CHIMPANZEE.

louder and louder, until it finally culminated in a series of yells and screams, not unfrequently accompanied with a stamping of the feet and a violent shaking of the netting of her cage. After this climax the utterance of a few grunts terminated the performance.

It occurred to Dr. Romanes (from whose account Mr. Lydekker quotes) that "Sally" would be a good subject on which to test the powers of an ape's intelligence. He found, however, that his experiments were seriously hampered by the effects on the creature of the visits of the numbers of people who were constantly passing in and out of the room in which she was kept, and there is consequently little doubt that under more favourable circumstances the results obtained would have been more remarkable than they are. Having secured the assistance of the keepers, Dr. Romanes requested them to ask "Sally" repeatedly for one, two, or three straws, which she was to pick up and hold out from among the litter strewing her cage. The number of straws asked for was constantly varied and never followed any regular order, and when the correct number was presented the animal was rewarded by a piece of fruit, while if the number was incorrect her offer was refused. In this way the ape was easily taught to associate these three numbers with their names. Lastly, if two or three straws were demanded she was taught to hold one or two in her mouth until she had picked up the remaining straw, and then to hand the two or three straws together. This prevented any error arising from her interpretation of vocal tones. As soon as she understood what was required, and had learnt to associate these three numbers with their names, she never failed to give the number of straws asked for. Her education was then extended in a similar manner from three to four, and from four to five straws. Here Dr. Romanes allowed her education to terminate. But one of her keepers endeavoured to advance her instruction as far as ten. Although she very rarely made a mistake in handing out one, two, three, four or five straws, and was usually accurate in handing out as many as six or seven, when the numbers eight, nine or ten were named the result became more and more uncertain, so as to be suggestive of guess-work.

It was evident, however, that she understood the words seven, eight, nine and ten to betoken numbers higher than those below them; and if she was asked for any of these numbers, she gave some number that was above six and not more than ten. On the whole, therefore, while there was no doubt that "Sally" could accurately count up to five, beyond five her accuracy of computation became progressively diminished. Owing to the method of picking out the straws above described, the operation was a slow one, and imposed a considerable tax upon her patience; and as her movements were deliberate and her store of patience small, Dr. Romanes thought that the uncertainty which attended her dealing with the numbers six and seven was more frequently due to her losing patience than to her losing count, although after seven he believed that her computation of the numbers became vague.

We heartily concur with the popular Secretary of the Zoological Society in commending "The Royal Natural History," not only to every naturalist, but to every lover of nature.

Our Household Insects: an account of the Insect Pests found in Dwelling-Houses. By Edward A. Butler, B.A., B.Sc. (Lond.), Author of "Pond Life," "Silkworms," &c. (London, Longmans, Green & Co.).—Mr. Butler is already well known to the readers of KNOWLEDGE, and they will welcome this collection of his papers, issued in book form, and provided with an index. We usually associate the pursuit of entomology with summer weather and the open air; but Mr. Butler's book will afford occupation for winter evenings, without imposing on readers the necessity of going very far from their own firesides; though it is to be hoped that they will not meet in their homes with specimens of every insect described by him. Thanks to the spread of education, and to the improved observance of the precept that "cleanliness is next to godliness," fleas, bugs and lice are now practically banished from most middle-class dwellings. On the other hand, there are no houses in which representatives of some of the insects whose history is related in this book cannot be found. The common cockroach (otherwise known as the black beetle) is, perhaps, the largest and best known of all household insects; and Mr. Butler wisely devotes some thirty pages to a sketch of its life-history and anatomy. As it is the largest of household insects, it is the best of them for dissecting purposes, and its internal organs can be studied without the use of a high power microscope; and with the advantages of Mr. Butler's guidance, any ordinary observer who has not first-class appliances can obtain some practical knowledge of the digestive, circulatory and nervous systems of the insect world. As Mr. Froude has attempted to whitewash Henry VIII., so does our author attempt to whitewash the wasp; but we fear that suspicion of wasps is so deeply rooted in the human breast that it will be long before men, and especially women, will learn to regard a wasp with equanimity, and to look upon him as a benefactor to mankind. Why do we always speak of the wasp as "he"? As a matter of fact, the male wasp is without a sting, and can be easily distinguished from the female and from workers by his antennæ, which are longer than theirs; but when a wasp is buzzing, who stops to consider the length of his antennæ? The ladies of the household will be interested in studying the various clothes moths, of which at least four species are known, though probably more species suffer from the mistaken zeal of the housewife when she is defending her beloved stores of linen and furs; and it should be remembered that when she discovers the moth issuing from the cupboards the mischief is already done, for the winged moth does not damage clothes, it merely lays the eggs from which come the caterpillars, who are the destructive agents. It is pleasant to find that some of the best known and most noxious household pests are importations to this country, and are not aborigines. The cockroach and the bed bug were unknown in England till the sixteenth century. By the way, these two insects are deadly enemies, and in the London slums the cockroach proves himself a friend of man by devouring numbers of bugs. Mr. Butler tells us of other insects that have not been acclimatized, but have been brought to this country in packages of foreign goods. He has discovered a fine large South American weevil in a gooseberry tart; and I remember sitting beside a friend when he found a Russian beetle in a cranberry pie. In England we think with disgust of savages who are in the habit of eating insects; but beetles and meal-worms are frequently ground up with corn into flour, and are not detected in bread and pastry, and it is not only corn which is liable to be thus adulterated. A recent writer says, "I have known bushels of cocoa nuts, which were every one worm-eaten and full of maggots, with their webs, cast-off skins, pupæ, and cocoons, all ground down to make chocolate—flavoured, I suppose, with vanilla."

Mr. Butler's method of writing will stimulate many to observe for themselves. We trust that he will not let the pen drop from his fingers, but will continue to instruct us in the habits of insects with the same charm of style and accuracy of observation which this book displays.

Oxford. A. BALLARD.

XUM

Weather Lore: A Collection of Proverbs, Sayings, and Rules concerning the Weather. By Richard Inwards, F.R.A.S. (London: Elliot Stock, 1893). Mr. Inwards' handsome book, of nearly two hundred pages, contains an interesting mine of weather lore. Many of the proverbs afford evidence of keen observation, though most may be said to be only of interest as they point to ancient superstitions and the universal tendency of mankind to form general conclusions from a too limited observation of facts. Mr. Inwards notes that a great many proverbs about the weather come from Scotland, and but very few from Ireland. He has collected the "fossil wisdom" about the weather from Roman and Saxon times onward, and notes that proverbs concerning particular days must, on account of the reformation of the calendar, be held to refer to times a little later than the dates now affixed.

Science Notes.

Mr. Enock, in the *Entomologist*, seems to forebode a plentiful crop of Hessian fly this year. The farmers, he says, are actually "sowing Hessian fly," by spreading the screenings from the threshing machine with the rough manure. He suggests *free* distribution of illustrated sheets by the Board of Agriculture; but one is tempted to ask, what is the Royal Agricultural Society doing?

Every student of astronomy has read of the luminous outburst observed upon the sun by Messrs. Carrington and Hodgson in 1859, and the magnetic disturbances which were supposed to be caused by it or to be simultaneous with it. Two brilliant objects appeared upon the sun, near the edge of a sunspot, and, after travelling a distance of about thirty-six thousand miles across the surface in five minutes, disappeared. There can be little doubt as to the accuracy of the solar observation, but the statement that the phenomenon was immediately followed by a magnetic storm does not appear to be founded upon fact, though the majority of astronomical text-books lay great stress upon the connection between the two phenomena. An examination of the case has led Mr. W. Ellis, of Greenwich Observatory, to the following conclusions: (1) The solar outburst in 1859 was seen independently by two observers; the fact of its occurrence seems, therefore, undoubted. (2) The corresponding magnetic movement was small. (3) Many greater magnetic movements have since occurred. (4) No corresponding solar manifestation has been again seen, although the sun has since been very closely watched. The erroneous impression has been long-lived, but apparently it must now be abandoned.

The probable origin of cannibalism has recently been discussed by H. Henkenius. He considers that hunger was the original incentive, and that the vice was persisted in from choice. Many writers are of opinion, however, that religious motives are accountable for the origin of the custom, and in Polynesia and Central America it certainly occurs most frequently in connection with religious ceremonials. Peschel has pointed out that tribes distinguished by a certain social and intellectual advance are frequently, up to a certain point, more cannibalistic than their less civilized neighbours; and this would support the view that one chief motive for the practice may be the rather complex idea of acquiring the strength and virtues of the fallen. The proceeding would certainly seem to be antagonistic to the instincts of the greater number of mammalian species, and to require as a condition such a conflicting incentive to these as a strong mental persuasion would supply.

A curious statement is made in the report of the Royal Commission on the Water Supply of the Metropolis. It is stated that disease-generating bacteria flourish better in distilled water, or water previously sterilized, than in ordinary river water where other bacteria, as for instance those engaged in putrefaction, are present. There is a natural antagonism between pathogenic and non-pathogenic bacteria. Hence where we have very pure water, such as is obtained from the deep chalk, an accidental fouling by infective matter may be more disastrous than if the supply were ordinary river water. This would tend to revolutionize our conception of the necessary conditions of safety in the matter of drinking water.

Letters.

[The Editor does not hold himself responsible for the opinions or statements of correspondents.]

COMPARISON OF STAR-PHOTOGRAPHS.

To the Editor of KNOWLEDGE.

DEAR SIR,—In the October and November numbers of KNOWLEDGE are letters from Mr. Glew and Mr. Wilson on a method of comparing different photographs of the same region of the sky, for detecting changes, by superposing a positive (on glass) from one of the negatives over the other negative.

I originally proposed this method in the *Astronomische Nachrichten* (No. 3101) nearly two years ago, and have used it before and since that time.

I enclose a copy of the *Nachrichten* containing my note on the subject, which I would thank the Editor if he would kindly reproduce in KNOWLEDGE, as it seems not to have reached the eyes of some readers, though it was noticed by several astronomical journals when it was published in the *Nachrichten*.

Mount Hamilton, California, E. E. BARNARD.
November 20th, 1893.

A simple and rapid method of detecting changes on celestial photographs due to motion or variability of the celestial bodies. By E. E. Barnard.

"The general adoption of photography for the charting of the heavens suggests the desirability of some means of facilitating the comparison of photographs of any one region on different dates, for the detection of change or variability.

"The most careful inspection of such plates by the ordinary methods would be laborious and would scarcely reveal changes unless they were very striking—repeated measurements of every object being out of the question.

"In thinking this matter over, it would seem that an admirable and almost instantaneous method is applicable where the photographs have been made with the same instrument—the scale remaining unaltered.

"Suppose two such photographs to have been made on different dates. From one of these negatives, say number one, make a glass contact positive. Superpose this upon negative number two—film to film. Since the scale in each case is the same, the superposed negative number two will completely blot out every image on the positive from number one, if in the meantime none of the objects has moved. If, however, any change has occurred, the images of the moving objects on the positive will not be obscured, and by holding the two plates, so superposed, to the light the eye will instantly detect the fact by the unobscured image of the object on the positive from plate number one. Now if the interval between the dates of the two photographs is not so great that the moving object has left the region photographed, it can be easily found on plate number two by making a positive of that plate and superposing it on negative number one; the position of the object again being made evident by the unobscured image.

"It would seem that this method would be about the only one at all applicable to a photographic search for any planet exterior to Neptune, as the slow motion of such an object would prevent its trailing on the plate, and it could not possibly be distinguished from the multitudes of small stars on the photographs by ordinary inspection.

"Photographs made with an interval of a few years, and thus compared, would at a glance reveal displacements due to proper motions of the stars—assuming that the scale suffered no change in the meantime.

"Comparisons thus made would also readily reveal the presence of variable stars.

"In superposing two negatives of the same region of the sky, correctly oriented to each other, very singular and interesting systems of circles, &c., are formed. These change their positions and extent with every slight shifting of one of the negatives from exact coincidence with the other."

PHOTOGRAPHIC NEBULOSITIES IN THE MILKY WAY.

To the Editor of KNOWLEDGE.

DEAR SIR,—In the continuation of the photography of the Milky Way, one of the plates having shown near its edge a rather remarkable and large nebula where none had been previously recorded, I decided to give a specially long exposure on it, though the object fell in a blank region of the Milky Way, in one of the large dark areas. With the nebula in the middle of the plate, on October 13th, 1893, an exposure of seven hours was given, from 8h. 20m. to 15h. 20m. standard Pacific time. The instrument used was the Willard lens, with which all the Milky Way and comet photographs have been made. The aperture of this instrument is six inches and the focal length thirty-one inches.

The resulting picture shows a very singular and remarkable object—a straggling group of bright stars in the centre of a vast nebula over 2° in diameter. This nebula, which is roughly roundish, has numerous irregular vacancies and zigzag lanes in it, and seems to mingle indefinitely with masses of small stars and become part of them. As shown by the photograph, it occupies a very singular region, distantly surrounded by vast multitudes of small stars.

The group of stars itself is visible to the naked eye as a hazy spot, about 3° north-west of the variable μ Cephei. The brightest star in the group is D.M. + 56° 2617, whose position for 1855·0 is $\alpha = 21\text{h. } 34\text{m. } 29{\cdot}8\text{s.}$, $\delta = +\ 56°\ 49{\cdot}7'$, which may also be taken to represent the place of the nebula.

The bright star near the north-west corner of the unenlarged plate is α Cephei. Five degrees south, and a little west of α, is shown the red star Σ 2729, which is a beautiful double. Preceding Σ 2729 is the 6·5 magnitude star D.M. + 57° 2309. This latter star the photograph shows to be surrounded by a rather unsymmetrical dense circular nebulosity. The nebulosity is a little denser following the star. The position of this object for 1855·0 is $\alpha = 21\text{h. } 13\text{m. } 21{\cdot}1\text{s.}$, $\delta = +\ 57°\ 58{\cdot}9'$.

This was not previously known to be nebulous, though the nebulosity can be seen as a hazy glow about the star with the telescope. In the 36-inch the star itself is found to be a very unequal double. Two nights' measures give for it position angle 274·1°, distance 4·40″. The smaller star is about $13\frac{1}{2}$ magnitude.

I also send an enlargement which I have made of the central part of this plate showing the large nebula to better advantage, the magnification being about $2\frac{1}{5}$ times. This brings out very beautifully the singular structure of the sky in the region of the nebula. When viewed at a distance of a few feet the effect is enhanced; it is then seen that the sky (or Milky Way) is broken up into numerous black cracks or crevices. Looking at these peculiar features, I cannot well see how one can avoid the conclusion that they are necessarily real vacancies in the Milky Way, through which we look out into the blackness of space. I am aware that Mr. Ranyard is opposed to this view, and I would like to have his opinion of the real nature of these apparent crevices in the Milky Way, as shown on this particular plate.

Among the many curious things shown on this photograph, besides others which I have not the time to elaborate on, will be seen a curious arch of small stars close following the second brightest star in the nebula. About 3° following the nebula, and a little north, is a very singular elliptical dark opening surrounding an island of small stars.

In reference to nebulous stars, I would say that a photograph on September 17th, 1893, with three hours' exposure, shows ω Orionis to be nebulous; there is a curved spur of nebulosity running from the star north-westerly, and a larger mass some 20′ north of the star. λ Orionis is also nebulous, with the heaviest part of the nebulosity to the west. These are verified with the 12-inch.

Another picture, with a longer exposure, seems to show a large elliptical nebulosity attached to and extending southerly from α Orionis. This latter, however, must be verified by another and longer exposure, though the nebulosity, if real, is strong enough on the present plate.

Mount Hamilton, California, November 14th, 1893. E. E. BARNARD.

To the Editor of KNOWLEDGE.

DEAR SIR,—The interesting article on the solar faculæ, in the December number of KNOWLEDGE, prompts me to send you some results of my own recent experience with regard particularly to the reversals of the H and K lines on the sun's disc and in the prominences, these being in some respects at variance with the conclusions of M. Deslandres.

A careful examination of all the spectrum photographs I have obtained appears to show that, whilst every true facula giving a continuous spectrum reverses the calcium lines, other bright reversals are sometimes present, having no corresponding faculæ. In certain spot spectra, for instance, the reversals are found to be continuous over the whole of the disturbed region, very intense but single over the spots, and wider with a central absorption line in the neighbouring faculæ. As a rule, however, the umbra of a spot appears to give no calcium light. Thus, I should be inclined to agree that the forms photographed with H or K light by Prof. Hale, and recently also by myself, would be more correctly described as "faculous gaseous protuberances" than faculæ, for they evidently do not correspond exactly with faculæ.

Where I differ from M. Deslandres, however, is in regarding both kinds of reversal as ordinary prominences seen in projection upon the disc, and I think I have obtained ample evidence showing that this may be true only with regard to what I may call the eruptive reversals having no corresponding faculæ. According to my experience, the ordinary faculæ do not reverse the hydrogen lines. If these objects were really prominences one would expect to find the hydrogen line ϵ, the companion to H, of the same relative intensity as it is in the prominences at the limb; but I have failed as yet to find any trace of this line. Furthermore, I have several times

observed the facula reversal when at the limb without finding any prominence over it, and I think I may say that, as often as not, the calcium reversal ends abruptly in the chromosphere.

Again, the faculæ are concentrated in the zones of spot formation, and cover such vast areas as to present the appearance in Prof. Hale's beautiful photograph of two nearly continuous belts, one on each side of the equator, forcibly reminding one, as Prof. Hale has himself remarked, of the equatorial belts on Jupiter. The prominences, however, are by no means confined to this region; in recent years I have found them mostly developed in much higher latitudes, in zones which appear to drift from mid-latitudes towards the poles (see *Astronomy and Astro-Physics*, No. 105, p. 427). The prominences found in the faculous region, say ± 40°, are very sparsely distributed in longitude, and the area occupied by them is certainly much less than that covered by faculæ. Thus I do not think that there is any direct correspondence between these phenomena.

The comparatively rare metallic and eruptive prominences are, however, found almost exclusively in the spot regions, and I think it highly probable that these are developed from faculæ in disturbed regions, and it is to these that I should attribute such phenomena as the sudden veiling of a spot by calcium vapour, so well shown in the photographs taken by Prof. Hale on July 15th, 1892 (*Astronomy and Astro-Physics*, No. 110), and I will venture to predict that these eruptive reversals will show also the companion line to H reversed; thus distinguishing them from the true faculæ.

My conclusion, therefore, is that monochromatic photographs obtained by Prof. Hales' method in H or K light will show faithfully all the true faculæ, but that occasionally these forms will be masked by an overlying extension of calcium vapour or by a prominence of exceptional brilliancy. The ordinary prominences, I believe, cannot thus be photographed in projection upon the disc.

Yours truly,
J. EVERSHED.

To the Editor of KNOWLEDGE.

Gore Lodge, Glenageary, Co. Dublin,
5th December, 1893.

DEAR SIR,—Referring to your observations relative to my moonlight photograph, which you reproduced in your issue of this month, the camera used had no "cap" arrangement, and the shutter was closed by me before removing the camera from the position in which the exposure was made. I feel perfectly convinced that the plate received no such irregular exposure as you imagine; but it has been suggested to me that the lightning-like marks may be due to some phosphorescent insect having crawled over the lens or plate. Yours truly,

ROBERT R. LEVINGSTON.

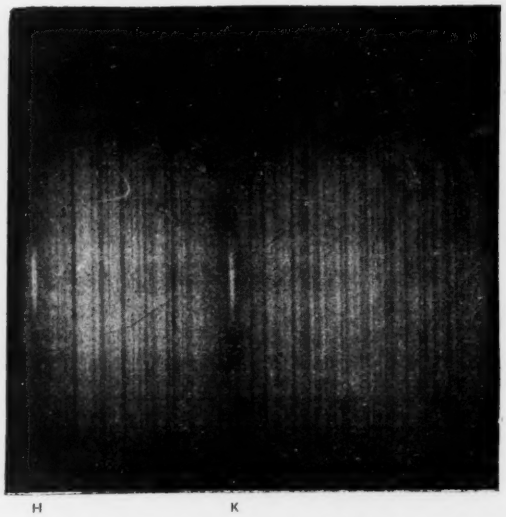
[If a phosphorescent insect had crawled over the lens during the exposure, its light might have thrown a faint general illumination on the whole plate; but no image of the insect would have been thrown on the plate. The fact that the lightning-like trace does not extend to the edge of the plate, but stops at the line which marks the edge of the dark slide, seems to show that the line was traced while the plate was exposed in the dark slide. Supposing that the light from a luminous insect crawling over the plate was sufficient to leave a photographic trace, one would expect the photographic action to be brightest at the centre of the path and to decrease in brightness gradually towards its edges; but the band on Mr. Levingston's plate has sharp edges. On the other hand, if the light was derived from a firefly in front of the camera, it must have been at a considerable distance, or its image thrown on the plate would have been out of focus and soft at the edges, in a camera which gave sharp images of a distant mountain; but it is hardly conceivable that a distant firefly would have been sufficiently bright to give such a trace, and we know from the breadth of the trace that the luminous object which caused it must have subtended about half a degree in diameter as seen from the camera.—A. C. RANYARD.]

THE SOLAR FACULÆ.

By Prof. GEO. E. HALE.

THE almost simultaneous discovery of the doubly-reversed H and K lines in the spectrum of the faculæ, made by M. Deslandres and myself in 1891, was not altogether unexpected. Several years earlier, Prof. Young had seen this bright pair of lines in the spectrum of spots, but their position at the extreme limit of the visible spectrum made satisfactory observation impossible. Prof. Young found, however, that the bright lines were not confined to the spot itself, but extended on to the disc for a considerable distance.

With the application of photography the difficulties of visual observation disappeared, and the bright lines were found, not only in the neighbourhood of spots, but also in extensive regions irregularly distributed over the solar disc. A dark central line of double reversal, which had escaped the eye of the observer, was also clearly registered upon the photographic plate. With a sufficient dispersion it is occasionally found that the doubly-reversed lines extend entirely across the sun. They are not uniformly bright, but have alternate maxima and minima of intensity. In the minima the lines sometimes seem to disappear completely, but it appears probable that with sufficient dispersion they could be photographed at any point on the disc. The accompanying cut, which is a direct reproduction of an enlarged photograph of the K



line (H is just on the edge of the field), will perhaps give an idea of the character of the double reversal. On the original photograph the lines are unbroken throughout their whole length, and of nearly uniform intensity on either side of a strongly-marked maximum. H and K are

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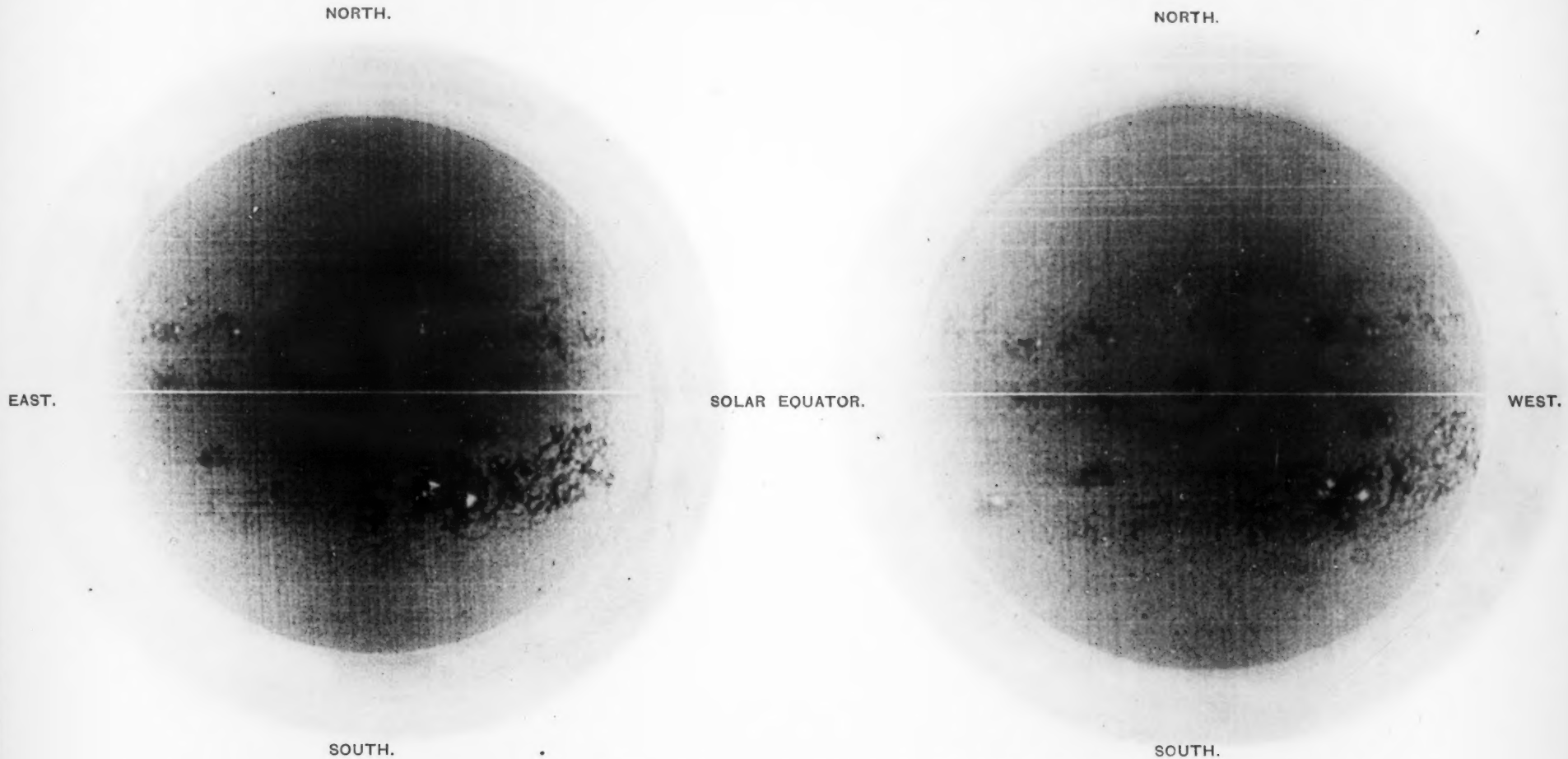

MONOCHROMATIC IMAGES OF THE SUN, dark representing light, showing the regions in which the Calcium line K is bright.

Photographed with a moving slit by Prof. GEO. E. HALE, at the Kenwood Physical Observatory, Chicago, U.S.A.

Direct Photo-Engraving Company, 9, Barnsbury Park, N.

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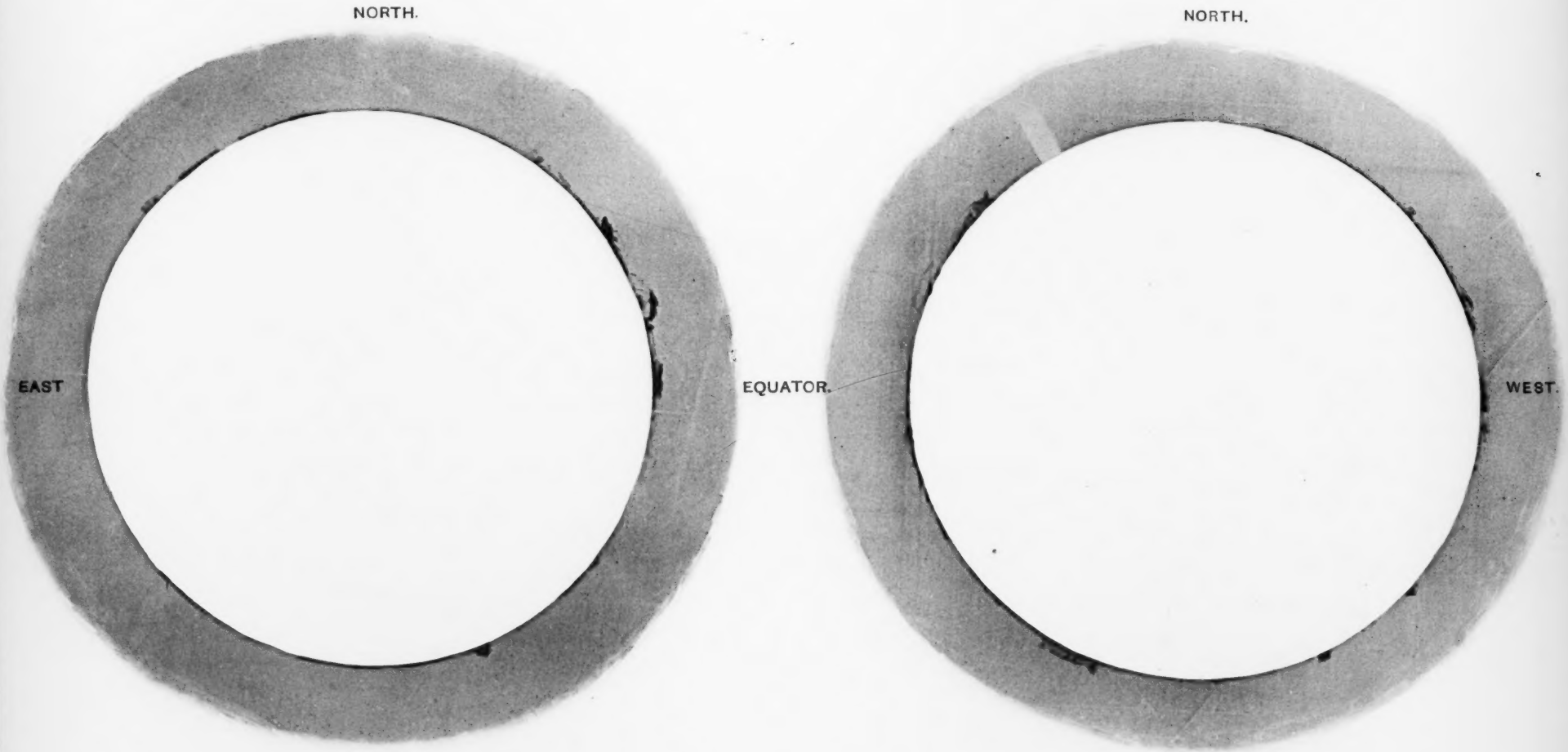

TWO SPECTROGRAPHS OF THE SOLAR CHROMOSPHERE AND PROMINENCES.

Photographed with a moving slit on the K line by Prof. GEO. E. HALE, at the Kenwood Physical Observatory, Chicago, U.S.A.

Direct Photo-Engraving Company, 9, Barnsbury Park, N.

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almost identical in appearance, except that the latter is always the brighter of the two.

The question has been raised as to whether the bright lines with dark centres are true double reversals, or simply close double lines. A moment's consideration of the facts of the case ought to leave no room for doubt on this point. If a photograph of the spectrum is taken with the slit lying across the sun's limb, it is found that the two bright lines of the double reversal unite into a single bright line at the edge of the disc, and this single bright line exactly coincides in position with the central dark line of the double reversal. This is shown in the photograph from which the cut was made, but the reproduction fails to bring it out.

The investigations of Cornu and other physicists, on the reversal of the lines of metallic vapours in the electric arc, offer most striking analogies to the phenomena just described. Through the kindness of M. Cornu, I have recently had the pleasure of examining some of his photographs of reversed lines. The investigations were confined to the ultra-violet, and the calcium lines which correspond with H and K were not specially studied. The reversals of other lines are similar, however, and will serve our present purpose equally well. An ultra-violet line of aluminium on one of the photographs reproduces the solar H and K reversals so perfectly that it might readily be mistaken for one of them, were there any doubt as to its mode of production.

In M. Cornu's experiments an image of the arc was formed on the slit of the spectroscope. A portion of the metal, or one of its salts, was introduced into a cup-shaped cavity in the lower carbon, and vaporized by the passage of the current. Under these conditions the central portion of the arc, where the line of sight passed through the cool exterior vapour to the intensely heated vapour and the glowing carbon poles, showed the aluminium line reversed—two narrow bright lines enclosing a narrow dark line. At the edge of the arc, however, where the line of sight passed through only the cooler vapour of the exterior, the two bright lines united into a single bright line, corresponding in position with the dark line seen in the first case.

We thus arrive at a basis for the interpretation of the H and K reversals in the sun. In the arc we have a reversed line produced by the absorption of the cooler vapour of the exterior. The chromosphere would seem to play the part of the absorbing vapour in the sun. At the base of the chromosphere, or below it, is the hotter vapour corresponding with that at the centre of the arc. Here is the seat of the brilliant radiation of calcium, which produces the two bright components of the doubly-reversed H and K lines. The upper part of the chromosphere, on the other hand, acts as an absorbing screen, and produces the central dark line of the reversal. A photograph of the solar disc secured by means of the spectro-heliograph (using the K line) should therefore show, not the entire chromosphere, but only its lower and hotter parts.

The distinction is an important one when it is remembered that photographs taken with the spectro-heliograph show the entire surface of the sun to be mottled over with small, irregularly-shaped, bright regions, which seem to form a nearly unbroken reticulation (*Astronomy and Astro-Physics*, May, 1893, p. 450). This is not to be mistaken for the well-known "granulation," nor for the "réseau photosphérique" of M. Janssen. Neither does it seem at all probable that the brighter regions are merely elevations in the chromosphere, for if the upper part of the chromosphere acts as an absorbing medium, and produces the dark central line of the H and K reversals, an increase in the depth of the chromosphere would certainly not diminish the absorption. It seems likely that the reticulation represents a true facular network, for the small faculæ seen without the spectroscope near the sun's limb, and well described by Secchi (*Le Soleil*, German edition), are probably parts of the same reticulation. Probably no sharp distinction can be made between the base of the chromosphere and the upper surface of the underlying faculæ. The latter seem to be in intimate connection with the interior of the sun, and one might therefore expect to find the H and K lines very bright in them.

In this connection it should be remarked that the H and K lines over spots are frequently somewhat narrower and less brilliant than on the disc, and the central dark line is often absent. I have explained this as probably due to the fact that we are here dealing with the radiation of the chromosphere overlying the *cooler* region of the spot. (*Astronomy and Astro-Physics*, 1892, p. 815.)

In a recent paper on the "Physical Constitution of the Sun" (*Astronomy and Astro-Physics*, 1893, p. 832), Father Sidgreaves has expressed his belief that faculæ are prominences seen in projection on the solar disc, and M. Deslandres has advocated a similar hypothesis in the December number of KNOWLEDGE (see also *Comptes rendus*, Nov. 27th, 1893). As my own position in regard to the subject is evidently not fully apprehended by M. Deslandres, I shall endeavour in what follows to state it as clearly as possible.

In a note dated January 18th, 1892 (*Astronomy and Astro-Physics*, February, 1892, p. 159), I wrote as follows in regard to the regions on the sun's surface in which I had found the H and K lines to be doubly reversed: "On January 12th, 1892, it was found possible to photograph the *forms* of some of these reversed regions, using a moving slit apparatus just completed for our large diffraction spectroscope by Brashear. The K line in the fourth order spectrum was employed, as is customary in the case of prominences. The reversed regions are of great extent, and in appearance closely resemble faculæ. Several explanations may be suggested to account for them. They may be:—

"1. Ordinary prominences projected on the disc.

"2. Prominences in which H and K are bright, while the hydrogen lines are absent.

"3. Faculæ.

"4. Phenomena of a new class, similar to faculæ, but showing only H and K bright, and not obtained in eye observations or ordinary photographs because of the brilliant background upon which they are projected."

Subsequently I found, by comparing photographs of faculæ near the sun's limb, made at the focus of a telescope in the ordinary manner, with photographs of the reversed regions made with the spectro-heliograph, that there was a very close agreement in form. For this reason I adopted the provisional name "faculæ" in subsequent references to the bright regions shown on spectro-heliograms, reserving an exhaustive discussion of the phenomena until sufficient material had been collected for that purpose. Part of this material, in the form of about three thousand spectro-heliograms and several hundred ordinary photographs of the sun, has already been collected and partially reduced. It is intended that one of the first volumes of publications to be issued by the Yerkes Observatory shall be devoted to a discussion of these results. At the present time, and at a distance from my photographic and other records, I can discuss the subject only in a provisional way.

XUM

No one can doubt that prominences, and particularly eruptive prominences, are closely related to faculæ. To this point I have already called attention in the following words: ". . . In a great many photographs taken with the spectro-heliograph, faculæ are shown projecting above the sun's limb. And the intimate relationship between faculæ and eruptive prominences is not less evident, especially in composite photographs showing faculæ and prominences on the same plate. When we consider that *eruptive* prominences probably rise from faculæ, it is not at all surprising that such prominences sometimes show a continuous spectrum in addition to their bright lines. For a violent eruption would naturally carry up with the prominence some "dust-like" matter from the facula, which would give a continuous spectrum." (*Astronomy and Astro-Physics*, November, 1892, p. 815.)

The projection of faculæ at the limb, while very frequently shown in short exposure photographs* of the sun's disc, is rarely much greater than the average depth of the chromosphere. If faculæ are prominences seen in projection, or if they are always covered by prominences, as Father Sidgreaves and M. Deslandres hold, these projections should be much higher—*i.e*, we should always find a prominence above one of these projecting faculæ. As a matter of fact, the long exposure spectro-heliograms of the chromosphere rarely show prominences at such points; when prominences are present they are almost invariably eruptive, and of small extent at the base. But the projecting faculæ give the reversed H and K lines, even when no prominence is present. M. Deslandres states, however: "Les facules sont, par définition, les plages brillantes de la surface solaire, plages qui, à l'intensité générale près, donnent les mêmes raies noires que les parties voisines, et correspondent aux parties élevées, aux montagnes de la photosphère. Elles sont distinctes des flammes de calcium audessus d'elles." (KNOWLEDGE, December, 1893, p. 230.)

It is probably true that the faculæ are ordinarily quite different from the prominences which sometimes cover them, but I cannot see that any evidence, other than a "definition," is offered to prove the absence of the bright H and K lines from their spectrum. These lines may have their origin in hot calcium vapour distributed through the mass of the facula, or confined to its outer portion,† but I by no means consider it proved that the spectrum of faculæ does not contain the bright H and K lines.

Leaving for a moment the question of faculæ, let us next consider whether prominences projected on the solar disc should be rendered visible by the spectro-heliograph. The reasoning which has already led us to the conclusion that the nearly continuous reversals of the H and K lines on the disc originate at the base of the chromosphere would seem to apply with greater force to the base of prominences, for here the H and K lines are apparently brighter than in the surrounding chromosphere. And, in fact, I have previously shown that certain outbursts on the solar disc, which, there is every reason to believe, are true eruptive prominences, have been photographed at the Kenwood Observatory with the spectro-heliograph (see *Astronomy and Astro-Physics*, 1892, p. 611; *ibid*, p. 920, Plate xlvi., photographs of the eruptive prominence of July 15, 1892; *ibid*, 1893, p. 454). Such brilliant outbursts are quite exceptional, only seven having been found in over two thousand spectro-heliograms.

While it is thus certain that some prominences can be detected on the sun's disc, it is equally certain that others cannot. Since January, 1892, bright regions in which the H and K lines are reversed have been found only in or near the sunspot zones. Not having access to our records, I cannot give the northern and southern boundaries of this facula zone with accuracy, but I do not think we have photographed a single bright calcium region more than 70° north or south of the equator. During the same period our photographs have shown great numbers of prominences of higher latitude than 70°, and prominences have not been uncommon in the near vicinity of the poles. Thus there are bright prominences which give no indication of their presence when projected on the disc, for by no flight of the imagination could the small and evenly-distributed meshes of the facular reticulation be supposed to represent the bases of such large and brilliant prominences. In the face of this difficulty I prefer to wait for further evidence before adopting the conclusion that quiescent prominences in the sunspot zones can be photographed when projected on the disc.

M. Deslandres has suggested that the reversals of calcium on the solar disc be called "*flammes faculaires*, nom qui est en accord avec les faits, et évite toute ambiguité" (KNOWLEDGE, December, 1893, p. 231; *Comptes rendus*, November 27th, 1893). I regret that, for the following reasons, I cannot consistently adopt this name:—

1. The use of the identical term "flame," commonly employed to describe one variety of chemical combination, is objectionable, because we do not know that the solar and terrestrial phenomena referred to are in any way similar.

2. I have offered evidence to show that many faculæ are not covered by prominences, but themselves give the H and K lines.

3. Even if it could be shown that all faculæ are covered by prominences, it would seem unnecessary to replace the well-known term "prominence" by a less satisfactory synonym.

For the present, if one does not wish to commit himself by speaking of faculæ and prominences on the disc, the general term "calcium reversals" may perhaps be used, though it is not altogether free from objection.

As to the electric origin of the bright H and K lines in the sun (Deslandres *loc. cit.*), it seems to me that the merely negative evidence at our disposal is not a safe foundation on which to build an argument. It is true that the hydrogen spectrum has not hitherto been obtained in the laboratory by the simple effect of heat, but it does not follow that this gas would not give a spectrum of bright lines when subjected to solar conditions. The H and K lines of calcium had not been obtained artificially without electrical means until I succeeded in photographing their feeble radiations in certain flames (see *Astronomy and Astro-Physics*, 1893, p. 452). At solar temperatures these radiations may be greatly strengthened, and the gradual shift toward the violet of the maximum of intensity in the calcium spectrum noticed with increased temperatures renders such a strengthening probable.

While it seems quite possible, and even probable, that electricity plays some part in solar phenomena, the evidence upon which to base any very positive statements appears to be lacking.

Before passing on to the discussion of certain practical

* Obtained with the spectro-heliograph and also by direct exposure at the focus of a telescope.

† It may even be that the lines originate in the chromosphere overlying the faculæ. In this case, the increased brightness of the lines, as compared with their brightness in other parts of the chromosphere, would have to be accounted for. Any such brightening, if due to the faculæ, would in all probability be confined to those parts of the chromosphere immediately overlying the faculæ, so that the form of the latter would still be obtained in spectro-heliograms.

questions, important in connection with future investigations of the sun, let us sum up some of the conclusions to which we have been led.

The faculæ are the elevated regions of the photosphere. They form an irregular reticulation over the entire surface of the sun,* and in the sunspot zones appear as irregular bright regions of varying extent. The spectrum of the faculæ is similar to the general spectrum of the sun, but is somewhat brighter, and contains the doubly-reversed calcium lines H and K.† The hot calcium vapour from which these lines emanate may be diffused throughout the mass of a facula, or confined to its upper surface. In the latter case, the base of the chromosphere and the upper surface of the facula would practically coincide. The white-hot particles giving a continuous spectrum would ordinarily be found only in the facula proper, and (more sparsely scattered) in the lower region of the chromosphere. *Eruptive* prominences are closely related to faculæ, and probably rise from them. It thus occasionally happens that a violent eruption carries some of the white-hot particles to a considerable distance above the photosphere. In such a case the prominence gives a continuous spectrum in addition to its bright lines. While some faculæ are covered by prominences, others do not appear to be so covered. Certain exceptionally bright eruptive prominences have been photographed in projection on the solar disc. Ordinary prominences in the region of the sun's poles are not shown in spectro-heliograms. Sunspots, even in their central parts, seem to be covered by the chromosphere (or by overhanging prominences). The chromosphere (or prominences) is frequently so bright as to completely hide small spots in spectro-heliograms.

As M. Deslandres has discussed the instruments and methods employed in my photographic investigations of the sun, I may perhaps be allowed to express an opinion as to the most advantageous manner of continuing these researches.

The spectro-heliograph used in the greater part of my photographic work has a pair of slits arranged to move in the focal planes of the collimator and observing telescope of a large diffraction spectroscope, attached to a 12-inch equatorial refractor.‡ It has proved itself a thoroughly practical instrument, and from two to twenty or more photographs of the forms of prominences and calcium reversals have been made with it on every clear day (with few exceptions) since January, 1892. The photogravure reproductions which accompany this article were made from negatives secured by the aid of this apparatus. Although they fail to bring out the more delicate details shown on the original plates, the illustrations surely demonstrate that the combination of a fixed spectroscope with two moving slits is not without certain merits. Neither my assistant, Mr. Ellerman, nor myself have experienced any difficulty in using a second slit 0·005 inch wide, and this width could be decreased were it considered desirable. By increasing the width of the second slit, and making a series of photographs of the K line at various points on the solar disc with the slit stationary, the character of the double reversals can be studied. This method of successive sections, which I first employed in 1891, seems to me quite as convenient as that used by M. Deslandres. As the slits always move together, there are no troublesome adjustments to be made by hand.

* At least during the maximum period of sunspots.

† The less refrangible hydrogen lines may also be present, but under ordinary conditions they are too faint to be recognized.

‡ This telescope will be removed to the Yerkes Observatory, where the spectro-heliograph will be employed, as at present, in securing a daily record of solar phenomena.

But after studying and experimenting with a great variety of instruments, I came to the conclusion early in the year 1893 that a spectroscope with collimator and observing telescope parallel (or nearly so) to each other, and slits fixed in the axis of each, the whole instrument being arranged to move on wheels at right angles to the axis of the large telescope, would possess important advantages over all other forms of spectro-heliograph. An instrument of this type, suitable for use with a heliostat for automatically photographing the sun, was described in my paper entitled "The Spectro-heliograph" (*Astronomy and Astro-Physics*, March, 1893, p. 256). I have since designed a spectro-heliograph on this principle for the 40-inch Yerkes telescope. A short description of this instrument will be found in the January (1894) number of *Astronomy and Astro-Physics*. The proposed "rotating spectroscope," for which M. Deslandres' various papers have claimed many advantages, has, I believe, been recently abandoned for a spectro-heliograph of this class. A similar instrument is to be used at the Maharajah Takhtasingji Observatory at Poona, India.

The question raised by M. Deslandres, in regard to the best dispersion to employ, is a most interesting and important one. On the one hand, a feeble dispersion would seem to offer important advantages on account of the narrowness of the K line and the greater brightness of the image. On the other hand, it must not be forgotten that the fainter details of the reversals may be lost if the dispersion is insufficient. M. Deslandres recognizes this fact when he states that the exceedingly faint H and K reversals in the general spectrum of the sun are best obtained with a "spectroscope puissant" (KNOWLEDGE, December, 1893, p. 231); and again, when he remarks that for the study of the details of the reversals on the solar disc "une grande dispersion est nécessaire" (*ibid*, p. 232). This advantage of high dispersion is due to the fact that the width of the bright lines is not proportional to the dispersion, at least up to a certain limit. If by doubling the dispersion the lines were doubled in width, there would evidently be no change in their brightness as compared with the solar spectrum in which they lie. But, within certain limits, the brightness of the lines relatively to the solar spectrum increases with the dispersion. It is evident, therefore, that we must not employ too feeble a dispersion. I have found the fourth order spectrum of a Rowland grating (14,438 lines to the inch) very suitable, though I should have preferred prisms had circumstances permitted their use. The separation of the H and K lines at the focus of the observing telescope, where the photographic plate is placed, is nine millimètres. M. Deslandres uses a single prism, giving a separation of H and K of two millimètres, and magnifies the image of the second slit—and, consequently, the width of the K line—three diameters. The resulting separation of H and K on his photographic plate would thus be six millimètres, and the width of the K line two-thirds the width of the K line in my instrument, if the line were supposed to have a width proportional to the dispersion. As has already been pointed out, the width of a line is not proportional to the dispersion, and it is probable that there is no great difference in the effective width of the line in the two instruments. Thus, any question in regard to displacement due to motion in the line of sight, width of the second slit, &c., would apply almost equally in both cases; but the greater dispersion of the grating would increase the brightness of the K line as compared with the solar spectrum, and fainter and more delicate calcium reversals should be obtained by its means.

It would probably be advisable to have a set of three

prisms for a spectro-heliograph, so that one, two, or three might be used as occasion required. The method of forming a magnified image of the second slit on the photographic plate, which we owe to Dr. C. Braun, formerly Director of the Haynald Observatory at Kalocsa, is in some respects a valuable one. Its principal defect—the widening of the K line and the second slit—can be avoided by enlarging the solar image before it enters the spectro-heliograph. In this case, however, it might not be possible to photograph the whole image on a single plate.

The large solar spectroscope which is to be used with the Yerkes telescope will be specially arranged for the study of the H and K reversals on the solar disc. Among the attachments to be employed for this purpose will be a pair of long slits, arranged to move in the focal planes of the collimator and observing telescope. The method of photographing the K reversal in successive sections of the disc will thus be similar to that hitherto employed with the Kenwood Observatory spectro-heliograph, but the exposures will be made automatically by an electrical device controlled by an astronomical clock. As I have already remarked, the spectro-heliograph for the Yerkes telescope will be arranged on another plan.

Berlin, December 15th, 1893.

THE FACE OF THE SKY FOR JANUARY.

By Herbert Sadler, F.R.A.S.

SPOTS and faculæ continue to appear on the Sun's disc whenever he is visible. Conveniently observable minima of Algol occur at 10h. 40m. P.M. on the 10th; at 7h. 29m. P.M. on the 13th, and at 4h. 18m. P.M. on the 16th.

Mercury is a morning star for the first portion of the month, but owing to his proximity to the Sun and great southern declination he will be very difficult to observe. On the 1st he rises at 7h. 0m. A.M., or 1h. 8m. before the Sun, with a southern declination of 23° 35′, and an apparent diameter of 5″, $\frac{20}{100}$ths of the disc being illuminated. On the 7th he rises at 7h. 22m. A.M., or 45m. before the Sun, with a southern declination of 24° 11′, $\frac{93}{100}$ths of the disc being illuminated. After this he is too near the Sun to be observed, coming into superior conjunction on the 29th. While visible he passes from Ophiuchus into Sagittarius, without approaching any bright star.

Venus is an evening star, a most brilliant object during the first three weeks of January in the south-western sky. She sets on the 1st at 8h. 0m. P.M., 4h. after the Sun, with a southern declination of 13¼°, and an apparent diameter of 34½″, $\frac{34}{100}$ths of the disc being illuminated. On the 11th she sets at 8h. 2m. P.M., 3h. 50m. after the Sun, with a southern declination of 9° 34′, and an apparent diameter of 40¼″, $\frac{26}{100}$ths of the disc being illuminated. She is now at her greatest brilliancy, that being precisely the same as on January 11th, 1886. On the 21st she sets at 7h. 51m. P.M., or 3h. 30m. after the Sun, with a southern declination of 6° 21′, and an apparent diameter of 47¼″, $\frac{17}{100}$ths of the disc being illuminated. On the 31st she sets at 7h. 19m. P.M., or 2h. 23m. after sunset, with a southern declination of 4° 12′, and an apparent diameter of 54½″, $\frac{9}{100}$ths of the disc being illuminated. Her brightness is now only $\frac{6}{10}$ths of what it was on the 11th. She describes a looped path in Aquarius during the month, being stationary on the 24th.

Neither Mars nor Uranus rise till after midnight in January; and as Saturn only rises on the 31st at 11h. 26m. P.M., we defer an ephemeris of him till next month.

Jupiter is an evening star, and, with the exception of Venus, is the brightest object in the evening sky. He sets on the 1st at 4h. 13m. A.M., with a northern declination of 17° 17′, and an apparent equatorial diameter of 45·0″. On the 12th he sets at 3h. 28m. A.M., with a northern declination of 17° 15′, and an apparent equatorial diameter of 43½″. On the 31st he sets at 2h. 16m. A.M., with a northern declination of 17° 27′, and an apparent equatorial diameter of 40·9″. He is almost stationary in a barren region between the confines of Aries and Taurus during the month. The following phenomena of the satellites occur while the planet is more than 8° above and the Sun 8° below the horizon:—On the 1st a transit ingress of the first satellite at 5h. 24m. P.M., and of its shadow at 6h. 24m. P.M.; a transit egress of the satellite at 7h. 36m. P.M., and of its shadow at 8h. 37m. P.M. On the 2nd an eclipse reappearance of the first satellite at 5h. 49m. 42s. P.M. On the 3rd a transit egress of the shadow of the third satellite at 5h. 12m. P.M. On the 7th an occultation disappearance of the second satellite at 0h. 38m. A.M.; a transit ingress of the first satellite at 0h. 45m. A.M.; an occultation disappearance of the third satellite at 0h. 48m. A.M.; a transit ingress of the shadow of the first satellite at 1h. 51m. A.M.; an occultation reappearance of the third satellite at 2h. 37m. P.M.; an occultation disappearance of the first satellite at 10h. 0m. P.M. On the 8th an eclipse reappearance of the first satellite at 1h. 16m. 31s. A.M.; a transit ingress of the first satellite at 7h. 18m. P.M.; a transit ingress of the second satellite at 7h. 21m. P.M.; a transit ingress of the shadow of the first satellite at 8h. 19m. P.M., and a transit egress of the satellite itself at 9h. 25m. P.M.; a transit ingress of the shadow of the second satellite at 9h. 33m. P.M., and a transit egress of the satellite itself at 9h. 42m. P.M.; a transit egress of the shadow of the first satellite at 10h. 32m. P.M., and a transit egress of the shadow of the second satellite at 11h. 54m. P.M. On the 9th an eclipse reappearance of the first satellite at 7h. 45m. 31s. P.M. On the 10th an eclipse reappearance of the second satellite at 6h. 23m. 1s. P.M.; a transit ingress of the shadow of the third satellite at 7h. 21m. P.M., and its egress at 9h. 14m. P.M. On the 14th an occultation disappearance of the first satellite at 11h. 51m. P.M. On the 15th a transit ingress of the first satellite at 9h. 3m. P.M.; of the second satellite at 9h. 50m. P.M.; a transit ingress of the shadow of the first satellite at 10h. 15m. P.M.; a transit egress of the first satellite at 11h. 16m. P.M. On the 16th a transit egress of the second satellite at 0h. 11m. A.M.; a transit ingress of its shadow one minute later; a transit egress of the shadow of the first satellite at 0h. 27m. A.M.; an occultation disappearance of the first satellite at 6h. 19m. P.M., and its eclipse reappearance at 9h. 41m. 24s. P.M. On the 17th a transit egress of the first satellite at 5h. 43m. P.M.; a transit ingress of the third satellite at 6h. 27m. P.M.; an occultation reappearance of the second satellite at 6h. 38m. P.M.; an eclipse disappearance of the second satellite at 6h. 43m. 46s. P.M.; a transit egress of the shadow of the first satellite at 6h. 56m. P.M.; a transit egress of the third satellite at 8h. 21m. P.M.; an eclipse reappearance of the second satellite at 8h. 58m. 52s. P.M.; a transit ingress of the shadow of the third satellite at 11h. 22m. P.M. On the 18th a transit egress of the shadow of the third satellite at 1h. 16m. A.M. On the 22nd an occultation disappearance of the first satellite at 1h. 42m. A.M.; a transit ingress of the first satellite at 10h. 54m. P.M. On the 23rd a transit ingress of the shadow of the first satellite at 0h. 10m. A.M.; a transit ingress of the second satellite at 0h. 20m. A.M.; a transit egress of the first satellite at 1h. 7m. A.M.; an occultation disappearance of the first satellite at 8h. 11m. P.M., and its reappearance from

eclipse at 11h. 37m. 17s. P.M. On the 24th a transit ingress of the shadow of the first satellite at 6h. 39m. P.M.; an occultation disappearance of the second satellite at 6h. 45m. P.M.; a transit egress of the first satellite at 7h. 35m. P.M.; of its shadow at 8h. 51m. P.M.; an occultation reappearance of the second satellite at 9h. 7m. P.M.; an eclipse disappearance of the second satellite at 9h. 19m. 31s. P.M.; a transit ingress of the third satellite at 10h. 13m. P.M.; an eclipse reappearance of the second satellite at 11h. 34m. 49s. P.M. On the 25th a transit egress of the third satellite at 0h. 10m. A.M.; an eclipse reappearance of the first satellite at 6h. 6m. 13s. P.M. On the 26th a transit egress of the shadow of the second satellite at 6h. 31m. P.M. On the 28th an eclipse reappearance of the third satellite at 7h. 3m. 36s. P.M. On the 30th an occultation disappearance of the first satellite at 10h. 4m. P.M. On the 31st a transit ingress of the first satellite at 7h. 15m. P.M., and of its shadow at 8h. 34m. P.M.; an occultation disappearance of the second satellite at 9h. 16m. P.M.; a transit egress of the first satellite at 9h.28m. P.M., and of its shadow at 10h. 47m. P.M.; an occultation reappearance of the second satellite at 11h. 39m. P.M., and its eclipse disappearance at 11h. 55m. 21s. P.M.

Neptune is an evening star, and is well situated for observation. He rises on the 1st at 1h. 56m. P.M., with a northern declination of 20° 37′, and an apparent diameter of 2·7″. On the 31st he rises at 11h. 57m. A.M., with a northern declination of 20° 34′. During the month he pursues a short retrograde path in Taurus, through a region barren of stars to the naked eye.

January is a favourable month for shooting stars, the most noted shower being that of the *Quadrantids*, the radiant point being in R.A. 19h. 12m. and 53° north declination, the greatest display being visible during the morning hours of January 1st to 3rd.

The Moon is new at 3h. 7m. A.M. on the 7th; enters her first quarter at 0h. 9m. A.M. on the 15th; is full at 3h. 11m. P.M. on the 21st; and enters her last quarter at 4h. 51m. P.M. on the 28th.

Chess Column.

By C. D. Locock, B.A.Oxon.

Communications for this column should be addressed to C. D. Locock, Burwash, Sussex, and posted on or before the 12th of each month.

Solution of Problem No. 3.

Key-move—1. B to K8.

If 1. . . . R to KR5, etc., 2. Q to Kt6ch.
1. . . . K to K4, 2. Kt × Pch.
1. . . . R to Q5, 2. B to Q7ch.
1. . . . R to Kt5ch, 2. Q × Rch.
1. . . . R to KB5, 2. Q × P, mate.

Dual after 1. . . . K to B5, by 2. Q to Kt3ch or 2. Kt × Pch.

Also after 1. . . . P to Q5, by 2. B to Q7ch or 2. Kt to Q5.

(There is also a dual mate in this variation.)

It is rather singular that no solver sent in *both* the above duals.

Solution of Problem No. 4.

Key-move—1. B to QKt6.

If 1. . . . K to Q4, 2. Q to KB2.
1. . . . K to Kt4, 2. Q to Q6.
1. , . . K to Kt5, 2. Q to K5.
1. . . . K to B6, 2. Q × P.

Solution of Problem No. 5.

Key-move—1. B to K3.

If 1. . . . B × P, 2. Q × BPch.
1. . . . K to K5, 2. Q to Kt5.
1. . . . K to K3, 2. Q to K7ch.
1. . . . P to B3, 2. Q to Kt5ch.
1. . . . Anything else, 2. B × Pch.

Some of our correspondents note the coincidence that these three problems, selected by ballot, are solved by moves of the Bishop. Still more singular is the fact that they were the first three problems sent in; and, what is more, sent in precisely in the order in which they were printed.

Correct Solutions received from the following:—

Ten Points.—Kt. J., F. R. Adcock, Semper, A. C. Challenger, H. Holmes, B. G. Laws, Chat, Guy.

Nine Points.—Birkenbaum, W. J. Jubb, Rascal, Buttercup, J. H. Christie, W. T. Hurley, A Norseman, E. W. Brooke, A. R.

Nos. 3 and 4 solved by Humilis (5); No. 3 by L. Bourne (4); No. 4 by H. S. Brandreth, Alpha, and W. A. Champion.

The leading scores will be published in tabulated form next month.

W. T. Hurley and *H. Holmes.*—The short mate takes precedence of others, which therefore do not count as duals.

Humilis.—Bird's *Chess History and Reminiscences* (Dean and Son) contains some curious information on the history of the game. There is no dual in No. 3 after 1. . . . R × Kt. If 2. QKt6ch, K to B5. 1. B to Q4 will not solve No. 4. Have you tried 1. . . K to K5?

W. J. Jubb.—Third-move duals do not count in the score.

Rascal.—Is not your award of first prize rather premature?

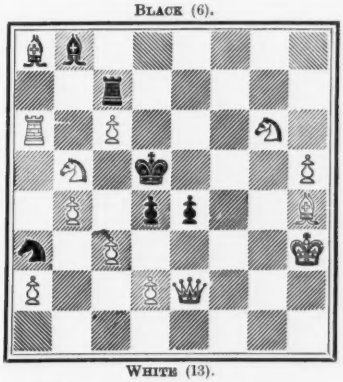
L. Bourne.—No. 4. If 1. Q to QB2, P to Kt3 seems a good defence.
No. 5. If 1. Kt(B6) to K7ch, K to K3 (best).

A Norseman.—Solutions bearing post-mark of the 12th are just in time. It would be impossible to give any extension to suit particular cases.

Position No. 6.

"*La Retraite.*"

Black (6).



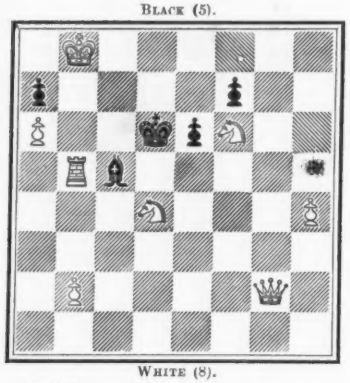
White (13).

White mates in three moves.

POSITION No. 7.

"*Cave Coquum.*"

BLACK (5).



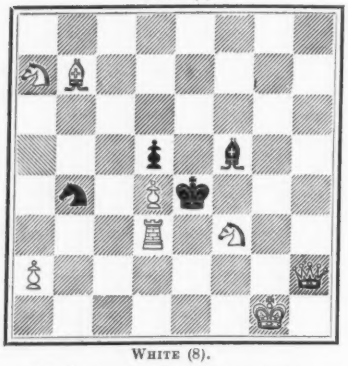
WHITE (8).

White mates in three moves.

POSITION No. 8.

"*Morceau.*"

BLACK (4).



WHITE (8).

White mates in three moves.

The following is the twenty-first game of the St. Petersburg match:—

QUEEN'S PAWN OPENING.

WHITE (Dr. Tarrasch).	BLACK (M. Tschigorin).
1. P to Q4	1. P to Q4
2. P to K3	2. Kt to KB3
3. B to Q3	3. P to K3
4. Kt to KB3	4. P to B4
5. P to QKt3	5. Kt to B3
6. B to Kt2	6. P×P
7. P×P	7. B to Q3
8. Castles	8. Castles
9. QKt to Q2	9. B to Q2
10. P to B4	10. R to Bsq
11. R to Bsq	11. B to B5
12. R to Ksq	12. Kt to K2
13. P to Kt3	13. B to Ktsq
14. Kt to K5	14. B to B3
15. B to Ktsq	15. B×Kt
16. P×B	16. Kt to Q2
17. Q to R5	17. P to KR3
18. QR to Qsq	18. Q to Ksq
19. Q to K2	19. Kt to QB4
20. P×P	20. B×P
21. Kt to B4	21. Q to B3
22. Kt to Q6	22. QR to Qsq
23. R to Bsq	23. P to KKt3
24. P to QKt4	24. B to B6
25. Q to Q2	25. P to Kt3
26. P×Kt	26. P×P
27. Q×RP	27. R to Ktsq
28. B to K4	28. R×B
29. B×Q	29. Kt×B
30. Kt to K4	30. B×Kt
31. R×B	Resigns

A NOTE ON CASTLING.

1. *Its advisability.*—Castling is usually to be recommended when the Queens and three or four other pieces are on the board; also where the opponent has two Rooks and minor pieces. If he has only one Rook and two or three minor pieces, it is generally better not to castle, but to come out with the King towards the centre of the board. Castling should often be delayed as long as possible. Nothing is so embarrassing to the adversary as uncertainty as to the future position of one's king. Of course, delay is useless when it is obvious on which side the castling must eventually take place.

2. *Its objects.*—The objects of castling are three: (*a*) To bring the Rooks into play (*b*), to protect the King, (*c*) to protect the Pawns on one wing by means of the King. The third of these objects is often lost sight of.

3. *Which side to castle.*—This, of course, depends almost entirely on the position, but there are certain theoretical considerations which apply in all or most cases. Theoretically, for *end-game* purposes, it is better to castle on the Queen's side, for the King is then usually within two squares of both K3 and Q3; while a King castled on his own side is *three* squares away from Q3. The chief objections to castling on the Queen's side are—(*a*) the QRP is left unprotected; (*b*) Black often gains time by a check with Queen or Bishop at KKt4, etc.

Much depends on what files are cleared. If the King's file and KB file are open, it is naturally best to castle KR and bring the QR to K square. If, on the other hand, the two centre files are open, as in most variations of Philidor's defence and the Scotch and Centre Gambits, time is often gained by castling QR and bringing the KR to Ksq.

When two players castle on different sides, the result is usually an advance of Pawns on one side or the other against the castled King. This advance is a slow process and often leads to nothing, the Pawns becoming blocked. There is a sign by which it may often be predicted. When a strong player, his opponent having castled KR, plays P to KR3 before castling, it generally shows that he has in view (Castles [QR] perhaps and) P to KKt4.

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